THE TELEGRAPHIC JOURNAL AND

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SECONDARY GENERATORS OR TRANSFORMERS.

WE hope shortly to be able to give some further information respecting the working of the secondary generators in the city of Tours, a description of the plant there employed having already appeared in our pages. The performance of these induction coils in the town above mentioned will be watched with all the more interest inasmuch that, if the information which has reached us is reliable, and this we have no reason to doubt, the Gaulard-Gibbs apparatus do not appear to give satisfaction at the Grosvenor Gallery.

We have never waxed enthusiastic over this current-transforming method of distributing electricity, although we freely admit that Messrs. Gaulard and Gibbs have achieved results which we but little anticipated. We still think, however, that their most favourable records between energy expended and energy returned occurred under conditions which will not be met with in practice. But it is not so much on the point of percentage of return that we desire to say a few words as upon the actual value of the apparatus for general use.

We understand that one of the principal faults to be found in the Grosvenor Gallery apparatus is that of very bad regulation, *i.e.*, if a given number of lamps, say 100, are fairly constant while all are in operation, very bad regulation ensues amongst the remainder if some 20 or 30 are turned out. If this is a fact, cannot something be devised to remedy a drawback so disagreeable and inconvenient to the consumer? Whilst we are now fairly conversant with the good and bad points of secondary batteries and can to a certain extent make provision against their vagaries, we are very much in the dark so far as any working data is concerned which deals with induction coils. Prof. Galileo Ferraris' elaborate report on these apparatus gave but little indication of what might be met with in commercial operations; and, if rumour speaks truly, there are yet many difficulties to be overcome before electrical transformers will be generally adopted.

It appears to us that for lighting over small areas their employment is not advisable, and that their real *forte* is in supplying power over long distances. Even in the latter case secondary batteries can be as readily made subservient to our desires; but induction coils have these advantages—they are doubtless very much cheaper than accumulators, and they are practically indestructible. Naturally the number of persons having any real experience in the working of transformers is exceedingly limited; when such practice becomes more general, the deficiencies now existing will be supplied if scientific opinion decides that there is a future for these apparatus.

SPANISH TELEGRAPHS.

THE Spanish Administration of Posts and Telegraphs has published the telegraph statistics for the half year ending June, 1885. We gather from it that during this period there has been a considerable diminution in the receipts, due it is said to very serious loss of crops, unusually severe storms, and notably to the cholera epidemic.

The following brief *resumé* of the information given in the report may be of interest:—

The peninsula is divided into six telegraph departments, among which are included the Balearic and Canary Islands, and are named, respectively, the Northern, North-Eastern, North-Western, Southern, Eastern, and Western divisions; these are subdivided into 13 telegraph centres.

The telegraph corps consists of 3,540 persons, all told, of whom only 45 are females. The principal officials are—an inspector-general chief of the telegraph department, an inspector-general chief of general service, 6 divisional or departmental inspectors, and 13 chiefs of centres.

During the six months ending June 30th, 1885, there were only 108 kilomètres of line constructed. At this date the Government lines consisted of:

17,596	kilomètres of	overhead lines,
129	„ „	underground cables,
236	„ „	submarine „

carrying the following lengths of conductors:

Overhead lines ...	42,981	kilomètres.
Underground cables	337	„
Submarine „	236	„

These figures do not include private lines, the lines belonging to railway companies authorised by Government to conduct public service, or telephone lines.

The report gives the number and nature of instruments employed on the Government lines as:

Morse	868
Hughes	20
Duplex	8
Translators	82

There is no account given of the instruments employed on lines other than Government, but it is stated that the railway companies chiefly use the Bréguet system.

During the six months referred to, there were 854 occasions on which the lines were interrupted for more than six hours, due to the following causes:—

Breaking of wire	212
Storms	421
Purposely	33
Unknown	188

Although the report gives the receipts, there is no account of the expenditure, so it is impossible to form any idea of the revenue accruing to the Government from its telegraph business.

The telephone system has been rapidly extending, and at the date already mentioned there were, besides 797 stations actually working, some 99 in course of installation. The receipts from the telephone service during the six months ending June 30th, 1885, amount to about £1,161, and the expenditure, which, however, counts from August of 1884, when a large increase of the telephone system was commenced, is given as £11,200. This amount includes, not only material already used, but sufficient for the continuation of the extension of the lines during the next six months.

PERMANENT COMMUNICATION WITH TRAINS IN MOTION.

RAILWAY accidents occur frequently enough to make it desirable that the question, so difficult, and yet so interesting and important, of permanent communication, telegraphic or telephonic, between trains in motion and the neighbouring stations should be solved. Without insisting on the evident utility of the solution of such a problem, we propose passing in review, writes M. Hospitalier, in *La Nature*, the principles of the devices proposed or tried hitherto, pointing out more particularly those which for about a year have produced some sensation in America, and, by report, in Europe. We shall speak only of permanent communication.

The idea of establishing permanent communication with trains in motion is by no means very recent. The first method proposed consisted in a special continuous rail laid down between two ordinary rails, on which a movable rubber established a permanent contact. A system thus constituted was experimented with for a month on a trial line laid down between Argenteuil and St. Cloud. It had to be given up in practice after a month's service.

A closer study of electric actions at a distance, the discovery of polarised relays, of electric diapasons, and lastly, that of the telephone have considerably augmented the resources of the electrical engineer. Several inventors have sought if it was not possible to utilise these novel discoveries by suppressing the permanent metallic communication and substituting for it inductive actions which are transmitted with great rapidity through all dielectrics, especially the air. This is the principle which characterises the new systems, already very numerous, and which may be divided into two great classes :—

1. Magnetic induction systems.
2. Electrostatic induction systems.

Each of these classes admits of sub-divisions founded on the nature of the transmitting and receiving apparatus, which in different cases are telegraphic relays, telephones, or a combination of both.

Magnetic Induction Systems.—The first apparatus for telegraphic communication with moving trains, based upon the principle of magnetic induction, was devised by Mr. L. J. Phelps, and established more than a year ago, by way of experiment, on a line of about 22 kilometres in length, at New York, between Haarlem River and New Rochelle junction. It has been in daily regular use ever since, and has recently prevented an accident by informing the conductor of a moving train that a preceding train had just broken its couplings, and that several of the carriages from the tail of this train were obstructing the line. The following is the principle of the Phelps system :—

A fixed conductor is placed in the middle of the space between the two rails ; it is insulated in a sheath of wood ; it communicates with the earth by one of its extremities, and with the manipulator of the station by its other end.

The manipulator allows a succession of long and short currents to pass along this wire, which currents act upon the movable induced circuit carried by the train.

This movable induced circuit is constituted by an elongated vertical bobbin with 90 folds, occupying the whole length of the telegraphic van and being about 2,400 metres in length, of which 1,000 metres are brought very near the conductor placed between the rails, and another 1,000 metres are as far removed from it as possible.

The free ends terminate in a telegraphic station installed in the van. Two cases are possible, according as the van receives or transmits messages.

For reception, the induced bobbin is connected to a very sensitive relay which closes the circuit of a local battery upon a sounder. For transmission, the battery is closed upon the induced bobbin by the intermediation of a buzzer, which sends a series of interrupted currents into the bobbin. These currents induce in the line a series of currents which affect a telephone at the receiving station, and enable Morse sound signals to be read. Mr. Phelps, considering that the telephone could not be employed as a recipient on the train on account of the noise, makes use of a relay and a sounder which produces clicks perceptible at 3 metres from the apparatus, even when the train is going at full speed.

The construction of the relay was very delicate, for it had to obey very feeble induced currents, and yet remain insensible to the shocks, vibrations, and other movements of the train, which are often very violent. This result was obtained by giving the armature a very slight mass, a very small momentum of inertia, and causing this armature to move in a very intense magnetic field, constituted by two powerful permanent magnets.

Hitherto, only permanent communications have been effected between a moving train and a station ; we conceive that it will be possible to establish a communication between two moving trains ; but, from a practical point of view, the question presents less interest, since the utility of communication exists especially between the train and the station from which it has been despatched, on which it is dependent until it enters another section.

Mr. Phelps had even foreseen the case of a station completely isolated placed in communication with the line by induction, by arranging a fixed induced coil of a suitable length parallel to the principal conductor. Such are the principles applied in the Phelps system.

Electrostatic Induction Systems.—Some years ago, about 1881, Mr. W. W. Smith thought that it would be possible to establish a permanent communication with moving trains by means of electrostatic actions, and he even took out a patent in this direction without carrying the matter further, until Messrs. Gilliland and Edison seized upon it, developed it, and rendered its application possible.

The principle consists in forming a vast condenser, of which one of the plates (fixed) is constituted by the telegraphic wires running along the line ; the other plate (movable) is formed by the metal roofs of the carriages, suitably insulated and connected with each other electrically, the dielectric being nothing other than the stratum of air comprised between the wires of the telegraph and the covers of the carriages. Whenever the potential of the telegraphic wires or that of the carriage covers is raised, this condenser with a movable plate is charged, and the charge of this condenser will produce a momentary current of charge which may be used to set a suitable receiver in action. In order to have sensible charges, capable of actuating receivers (since the capacity of the condenser is low), high potentials of charge must be employed, which may be effected by means of transformers.

The telegrams arrive at the stations in the form of Morse signals, received in two telephones, which the official posted in the train keeps to his ears in a permanent manner (fig. 1) by means of a head-band, which leaves his hands at liberty.

The combinations being very numerous, we shall content ourselves with indicating one of those which is most readily explained. Fig. 2 shows the arrangements of one of these stations, and fig. 3 that of the moving post in the train.

We see in fig. 3 that the post comprises four distinct circuits : 1, the circuit of a buzzer, worked by a special battery, P, and making about 500 electric contacts per second. This buzzer works continuously during the whole time of the transmission. 2. The circuit of a battery, P′, communicating with the thick wire inductor circuit of a transformer or induction bobbin, B, a bobbin into which are sent currents interrupted each time that the manipulator, M, is pressed. 3. The induced circuit of the bobbin, B, which in the position of transmission communicates by one extremity with the earth through the medium of the wheels of the carriage and of the rails, and by the other extremity with the insulated roof of the carriages by the medium

of the commutator, S. In the position of reception the induced circuit is open at S. 4. The circuit of the telephone, T, is connected to the earth by one end, whilst the other communicates with the roof of the carriages in the position of reception.

By pressing upon the key we induce, by the medium of the bobbin, B, a rapid series of currents of high tension, which communicate themselves to the line, or to the net of parallel lines, in the form of successive charges and discharges.

is driven into the line itself, whilst the other circuit is closed locally, either on the telephone in the position of reception or on the manipulator, and the buzzer in the position of transmission. This is the arrangement shown in fig. 4; the action is easily understood after what has been said concerning the other combinations.

As a matter of course, in all these applications the ordinary telegraphic wires are utilised without interfering with their own service. It is useful to apply to them the anti-inductive or graduative arrangements

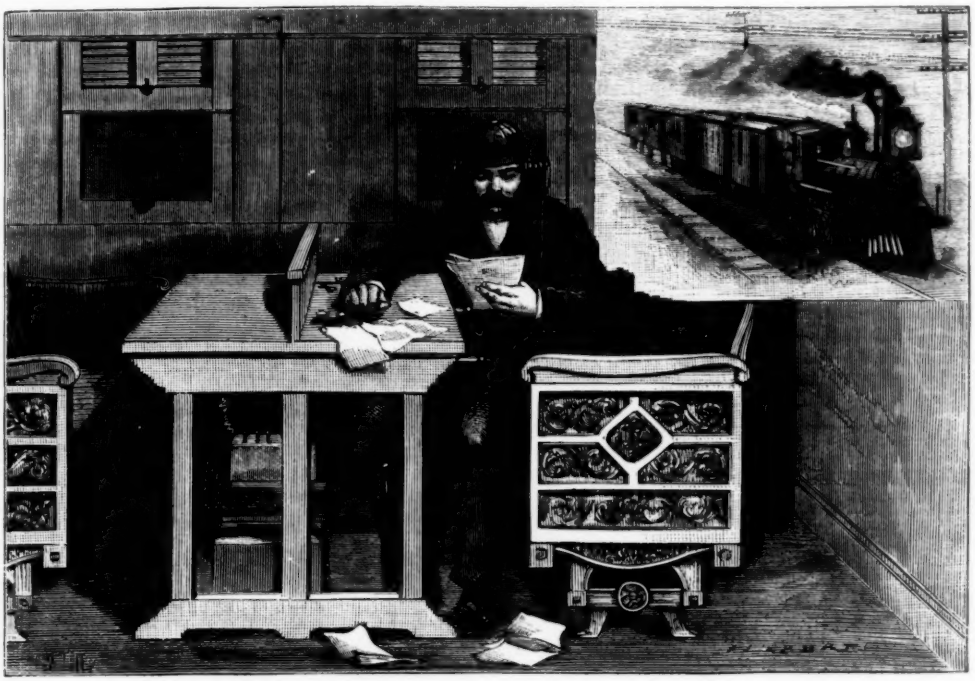


FIG. 1.

Telephonic communications with trains in motion, Edison's system. Official provided with a telephonic apparatus receiving a dispatch in a moving carriage.

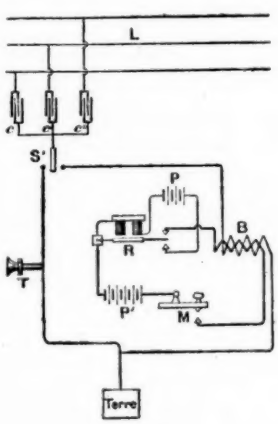


FIG. 2.

Post at the station with condensers.

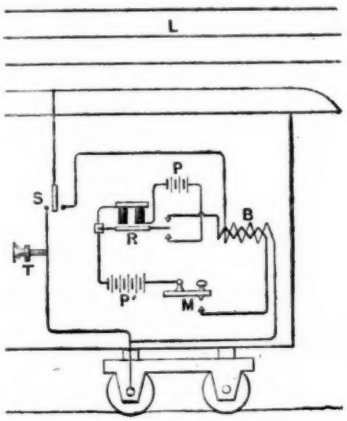


FIG. 3.

Post in the moving train.

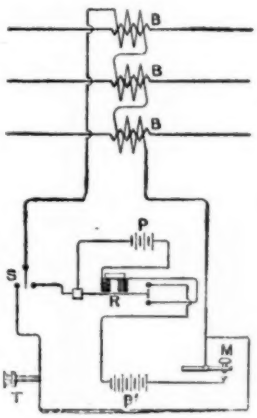


FIG. 4.

Post at the station with transformers.

Fig. 2 shows how these charges of the system of lines can, in turn, charge the condensers, c, c', c'', and finally influence the recipient telephone, causing it to return a true series of long or short sounds, according to the time during which the key of the manipulator, M, is pressed. The two posts are, moreover, absolutely symmetrical and independent, permitting at will reception or transmission at any post whatever.

We may also in the fixed station substitute for the condensers induction coils, one of the circuits of which

of M. van Rysselberghe, so that the ordinary telegraphic transmissions may not be perceived by the telephone.

Mr. Phelps, whose magneto-inductive system we have just described, has also patented new arrangements founded upon electrostatic actions. In one of these the buzzer or vibrator is suppressed as well as the induction coil, and the sounds are reduced to characteristic clicks at closing and breaking the circuit. Lastly, by substituting a microphone for the Morse

key, Mr. Phelps proposes to telephone to and from moving trains; but this is merely a project which has not yet received the sanction of experience.

The problem of a permanent telegraphic communication with moving trains may at present, therefore, be considered as solved. But does this mean that it is likely to receive an extended practical application? So far, we do not think so. It must not, in fact, be forgotten that the system immobilises one or more lines for a single communication, and that to effect several at once on the same conductors in different sections, it would be necessary to insulate these sections telephonically, to separate the messages on arrival, and, in a word, realise simultaneous musical telephonic transmissions.

If we may believe the American journals, these phenomena of charges and discharges have led Edison to a real discovery relative to the manner of the propagation of electric charges through the air.

According to him, the air is a conductor for an extremely brief fraction of time; but after this very short instant it is polarised by the passage of the current; its resistance is increased and it ceases to conduct.

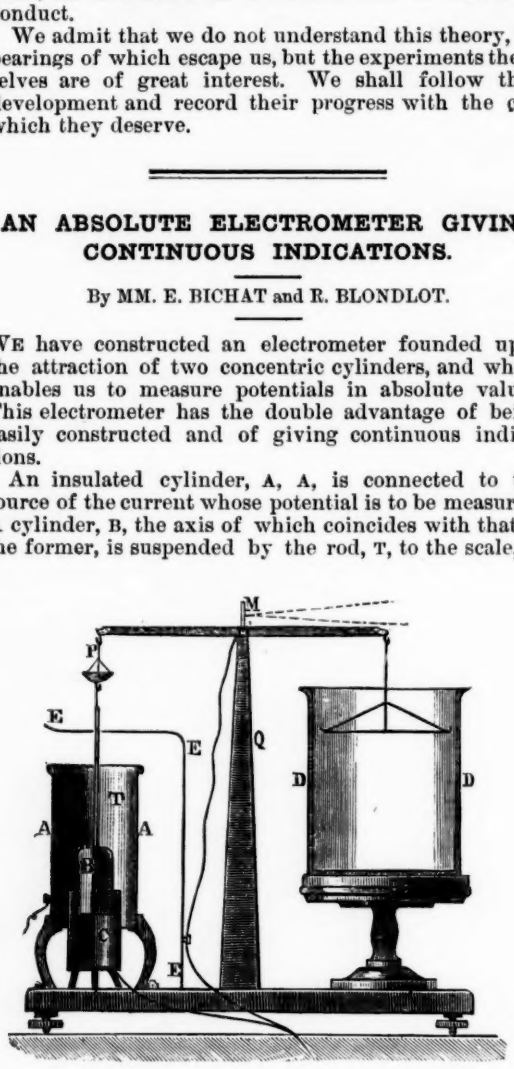
We admit that we do not understand this theory, the bearings of which escape us, but the experiments themselves are of great interest. We shall follow their development and record their progress with the care which they deserve.

AN ABSOLUTE ELECTROMETER GIVING CONTINUOUS INDICATIONS.

By MM. E. BICHAT and R. BLONDLOT.

WE have constructed an electrometer founded upon the attraction of two concentric cylinders, and which enables us to measure potentials in absolute values. This electrometer has the double advantage of being easily constructed and of giving continuous indications.

An insulated cylinder, A, A, is connected to the source of the current whose potential is to be measured. A cylinder, B, the axis of which coincides with that of the former, is suspended by the rod, T, to the scale, P,



of a balance, and communicates with the ground by means of the beam of this balance. The cylinder, B, B, plunges in part into a cylindrical vessel, C, rather larger in diameter and communicating likewise with the ground.

A screen, E, E, E, connected with the ground, allows the rod, T, to pass through an aperture; it serves to protect the balance against the attractions of the cylinder, A, A.

The cylinder, A, exerts upon the cylinder, B, a force directed from below upwards, which may be valued by following a procedure analogous to that employed by Maxwell for establishing the theory of Sir W. Thomson's quadrant electrometer. The totality of the cylinders, B and A, forms a condenser; the length of these cylinders being sufficiently great in proportion to their diameters at the mean part of the cylinder, B, and at the corresponding part of A, the distribution is the same as if they were infinitely long, that is, in this region the equipotential surfaces are concentric cylinders and the lines of force are the radii; above and below the distribution is different. If we suppose that the cylinder, B, projects out of C, by a quantity which is not too great, we may consider the change in distribution as having consisted in a simple prolongation of the portion in which the distribution is the same as if the cylinders were indefinite, the portion situate above, where the distribution is irregular, being simply displaced.

Let R and r be the respective radii of the cylinders A and B; V the potential of A, that of B being zero; let, further, F be the force which attracts the cylinder, B, from below upwards. Let us suppose that the cylinder, B, is raised by a quantity, dz, the work of the electric forces is then $F\,dz$. According to the theorem relative to the displacement of bodies of a constant potential this work is equal to the increase of energy of the system. But the increase of charge is the product of V by the capacity of a portion of an indefinite cylindrical condenser of the height, dz; it is therefore equal to

$$\frac{1}{2}\frac{V\,dz}{L\frac{R}{r}}.$$

In consequence the increase of energy is

$$\frac{1}{4}\frac{V^2\,dz}{L\frac{R}{r}}$$

and we have the equation

$$F\,dz = \frac{V^2\,dz}{4\,L\frac{R}{r}}.$$

Whence

$$V^2 = 4\,F\,.\,L\frac{R}{r}.$$

If we measure R and r in centimetres and F in dynes we shall have V^2 in absolute units of the C. G. S. system.

To measure F we put marked weights upon the scale, P, of the balance, until the equilibrium is re-established.

The value of these weights expressed in grammes, multiplied by the number g gives the force expressed in dynes.

In order to annul the oscillations of the beam we suspend in the place of the second scale of the balance a large pasteboard disc which rises and falls in a glass cylinder, D, D, of a rather larger diameter. The friction of the air renders the apparatus almost aperiodic.

The force, F, being, within wide limits, independent of the position of the cylinder, B, it results that we may also make use of this instrument without employing weights, by merely observing the inclination of the beam. A mirror, M, fixed above the knife edge enables us to measure this inclination by the process of reflection. When the equilibrium is established, F is equal to a constant multiplied by the tangent of the angle of inclination. This constant is determined, once for all, by putting in the scale, P, a known weight, the electrometer being discharged, and observing the corresponding deviation.

For small deviations the force, F, is proportional to the number of divisions which have passed before the cross wires of the telescope. A counterpoise, Q, movable along a needle fixed perpendicular to the beam enables the sensitiveness of the balance to be modified at will.

A calculation based upon the formula given by M. Blavier for the capacity of a condenser formed of two cylinders whose axes do not coincide, but are parallel, shows that a lateral displacement of the cylinder, B, even of two or three millimetres, has only an exceedingly small influence upon the value of the force, F. This is because F is at a minimum when the two cylinders are concentric. In our apparatus, where $R = 5{\cdot}875$ centimetres and $r = 2{\cdot}5$ centimetres, F varies only by 0·003 of its value for a deviation of the axes of three millimetres.

In the calculation made above for determining F, the rod T, supporting the cylinder B, has not been taken into account. The complete expression for F is obtained by deducting from the action upon B that which is exerted upon the rod. If we call ρ the radius of the latter, the factor by which we must multiply, the force to obtain the square of the potential is

$$4\left(L\frac{R}{r} - L\frac{R}{\rho}\right)$$

As a verification of the exactness of the indications of our apparatus we have determined the potentials corresponding to a certain number of explosive distances between two spheres: the numbers obtained agree perfectly with those determined with great precision by M. Baille.—*Comptes Rendus.*

ON A CONVENIENT METHOD OF FINDING THE CURRENT IN ANY EXTERNAL CIRCUIT DUE TO TWO OR MORE SOURCES OF E.M.F. IN ARC.

By E. C. RIMINGTON.

POLLARD'S theorem of a shunted battery is well known; it may be enunciated thus:—

When a battery of E.M.F., E, and internal resistance, ρ, is shunted with a shunt, S, it is equivalent to a new battery of E.M.F. $\frac{E\,S}{\rho + S}$ and internal resistance $\frac{\rho\,S}{\rho + S}$.

This theorem holds good whatever be the value of the external resistance, and also if it contain a source of E.M.F. Let us consider this latter case.

Let R be the external resistance and e the E.M.F. acting in it; let the latter be reckoned a positive quantity if it sends, or tends to send, a current in the external circuit in the same direction as the battery, E, and a negative quantity if in the opposite direction.

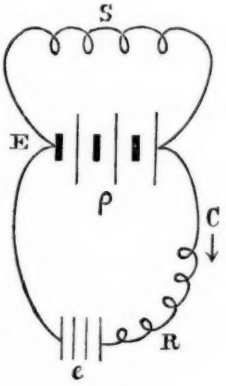


FIG. 1.

Let us suppose the shunted battery to be replaced by a new battery of E.M.F., E_1, and internal resistance, ρ_1, which gives the same current in the external circuit as the shunted battery.

Then if C be the current in the external circuit in the two cases,

$$C = \frac{E_1 + e}{\rho_1 + R}$$

in fig. 2.

By applying Kirchoff's laws to fig. 1 and solving for C, we obtain

$$C = \frac{E\,S + e\,(\rho + S)}{\rho\,S + \rho\,R + R\,S}.$$

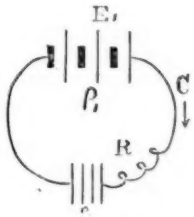


FIG. 2.

Dividing numerator and denominator of this by $\rho + S$ we have

$$C = \frac{\frac{E\,S}{\rho + S} + e}{\frac{\rho\,S}{\rho + S} + R} = \frac{E_1 + e}{\rho_1 + R}.$$

Now the only variables are e and R.

Therefore $E_1 = \frac{E\,S}{\rho + S}$ and $\rho_1 = \frac{\rho\,S}{\rho + S}$.

The principle of Pollard's theorem may be applied to the case of two dissimilar cells or batteries in arc in the following manner:—

Let E_1 and E_2 be the E.M.Fs. of the two batteries, and let them be quantities of the same sign if they send, or tend to send, currents through the external circuit in the same direction, and of opposite signs if in opposite directions. Let ρ_1 and ρ_2 be the internal resistances of the batteries and let R be the external resistance, which may have any value. Let C be the

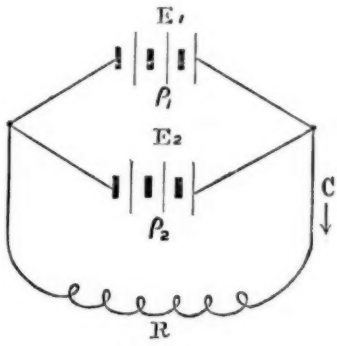


FIG. 3.

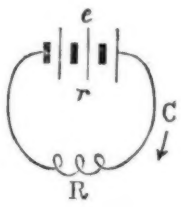


FIG. 4.

current in the external circuit. Then, by means of Kirchoff's laws, we obtain from fig. 3

$$C = \frac{E_1\,\rho_2 + E_2\,\rho_1}{\rho_1\,\rho_2 + R\,\rho_1 + R\,\rho_2} = \frac{E_1\,\rho_2 + E_2\,\rho_1}{\rho_1\,\rho_2 + R\,(\rho_1 + \rho_2)}.$$

Dividing numerator and denominator by $\rho_1 + \rho_2$ we have

$$C = \frac{\frac{E_1\,\rho_2 + E_2\,\rho_1}{\rho_1 + \rho_2}}{\frac{\rho_1\,\rho_2}{\rho_1 + \rho_2} + R}$$

Let e be the E.M.F. and r the internal resistance of another battery which sends the same current, C, through the same external resistance. Then from fig. 4

$$C = \frac{e}{r + R}.$$

Therefore
$$\frac{e}{r + R} = \frac{\frac{E_1 \rho_2 + E_2 \rho_1}{\rho_1 + \rho_2}}{\frac{\rho_1 \rho_2}{\rho_1 + \rho_2} + R}$$

Now since R is the only variable

$$e = \frac{E_1 \rho_2 + E_2 \rho_1}{\rho_1 + \rho_2} \text{ and } r = \frac{\rho_1 \rho_2}{\rho_1 + \rho_2}.$$

This result may be enunciated in the following manner :—

If there are two batteries in arc they are equivalent, as regards the external resistance, to a new battery whose E.M.F. equals the E.M.F. of one of them multiplied by the internal resistance of the other plus the E.M.F. of the latter multiplied by the internal resistance of the former, the sum being divided by the sum of their internal resistances; and whose internal resistance is the joint resistance of the two batteries.

This theorem will, like Pollard's, hold when there is an E.M.F. acting in the external circuit.

As an example of the application of this theorem we may take the case of Lumsden's method of comparing two E.M.Fs.

E_1 and E_2 are the two E.M.Fs. to be compared; R_1 and R_2 the total resistances of the branches in which they act; these we can regard as being the internal resistances of the batteries. G is a galvanometer. The test is made by adjusting the resistances, R_1 and R_2,

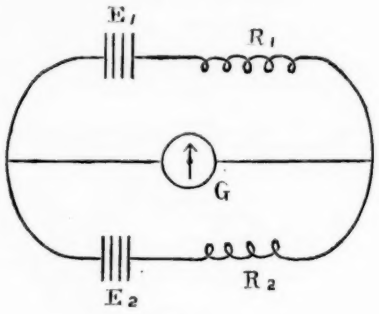


FIG. 5.

until there is no current passing through G. Regard G as the external circuit. Then current through G (fig. 5)

$$= \frac{\frac{E_1 R_2 + E_2 R_1}{R_1 + R_2}}{\frac{R_1 R_2}{R_1 + R_2} + G} = 0.$$

G is infinite or $E_1 R_2 + E_2 R_1 = 0$.

$$\therefore \frac{E_1}{E_2} = -\frac{R_1}{R_2}.$$

That is to say the E.M.Fs. must be of opposite signs as regards G, and be to one another as the resistances of the branches in which they act. As another example, suppose we have a three-branch circuit, the resistance of each of the branches being R_1, R_2, and R_3, and containing E.M.Fs. of values E_1, E_2, and E_3 respectively, the currents in each of the branches being C_1, C_2, and C_3 respectively.

We require to find the current in any one of the branches, *e.g.* C_1; treat the branch, R_1, in which we wish to find the current as the external circuit. Let the E.M.Fs. be reckoned positive quantities if they tend to send a current through R_1 in one direction (say from left to right) and as negative quantities if in the reverse direction.

Then

$$C_1 = \frac{\frac{E_2 R_3 + E_3 R_2}{R_2 + R_3} + E_1}{\frac{R_2 R_3}{R_2 + R_3} + R_1} = \frac{E_1 (R_2 + R_3) + E_2 R_3 + E_3 R_2}{R_1 R_2 + R_1 R_3 + R_2 R_3}$$

In the same way by treating $R_2 + R_3$ as the external resistances we can find C_2 and C_3.

If one of the batteries is of very low internal resistance compared to the other, the joint E.M.F. will be very nearly equal to that of the battery having the low internal resistance : since

$$\frac{E_1 \rho_2 + E_2 \rho_1}{\rho_1 + \rho_2} = \frac{E_1 \rho_2}{\rho_2} = E_1, \text{ if } \rho_1 \text{ equals zero,}$$

and if ρ_1 be very small compared to ρ_2 it can easily be seen that it will be very near this value. Also the terminal E.M.F. of the equivalent battery, or

$$E_t = \frac{E_1 \rho_2 + E_2 \rho_1}{\rho_1 + \rho_2} \times \frac{R}{\frac{\rho_1 \rho_2}{\rho_1 + \rho_2} + R} = \frac{(E_1 \rho_2 + E_2 \rho_1) R}{\rho_1 \rho_2 + R (\rho_1 + \rho_2)}$$

If ρ_1 is negligible compared to ρ_2 and also to R this becomes equal to E_1 practically.

An example of this is when secondary batteries are employed as regulators for incandescent lighting; the batteries, the dynamo (a shunt one), and the lamps being all put in arc. Here E_1 and ρ_1 represent the E.M.F. and internal resistance of the secondary batteries, and if their internal resistance be small compared to ρ_2 the resistance of the dynamo armature and R the external resistance which is the joint resistance of the lamp circuit and the shunt coils of the dynamo field-magnets, the terminal E.M.F. will remain practically constant even though considerable fluctuations take place in the value of the E.M.F. of the dynamo or E_2 owing to unsteady driving.

Let us suppose the initial E.M.F. of the dynamo or $E_2 = 101$ volts at the correct speed, its armature resistance is $\cdot01^{\omega}$; the internal resistance of the secondary battery is $\cdot001^{\omega}$ and its E.M.F. 100 volts; the external resistance is 1^{ω} and the required terminal E.M.F. is 100 volts, then when the dynamo is being driven at the proper speed no current is passing through the secondary batteries.

Now suppose the speed of the dynamo changes so that its E.M.F. becomes 105 volts, then we have

$$E_1 = 100,\ E_2 = 105,\ \rho_1 = \cdot001,\ \rho_2 = \cdot01,\ R = 1$$

$$\therefore E_t = \frac{100 \times \cdot01 + 105 \times \cdot001}{\cdot01 \times \cdot001 + 1 \times (\cdot01 + \cdot001)} = \frac{1 + \cdot105}{\cdot00001 + \cdot011}$$

$$= 100\cdot36.$$

So that an increase of 5 volts in the E.M.F. of the dynamo only produces an increase of ·36 volt in the terminal E.M.F.

Again, suppose the speed falls so that E_2 becomes 95 volts, then :

$$E_t = \frac{100 \times \cdot01 + 95 \times \cdot001}{\cdot01101} = \frac{1\cdot095}{\cdot01101} = 99\cdot45 \text{ volts.}$$

So that in this case a fall of 6 volts in E_2 only produces a fall of ·55 volt in E_t.

If we wish to find what values we must make the internal resistance and E.M.F. of the secondary battery so that a given alteration in E_2 may produce a given alteration in E_t we can proceed thus. We have

$$E_t = \frac{(E_1 \rho_2 + E_2 \rho_1) R}{\rho_1 (\rho_2 + R) + \rho_2 R}$$

transposing

$$E_1 = \frac{E_t \{\rho_1 (\rho_2 + R) + \rho_2 R\} - E_2 R \rho_1}{R \rho_2}.$$

Let E_2 become $E_2 + e$ [illegible] and let the terminal E.M.F. become $E_t + e_t$ where e_t is the greatest alteration we wish to have in the terminal E.M.F. from its normal value E_t, e being the greatest alteration in E_2.

Then

$$E_1 = \frac{(E_t + e_t) \{\rho_1 (\rho_2 + R) + \rho_2 R\} - (E_2 + e) R \rho_1}{R \rho^2}$$

$$\therefore (E_1 + e_1)\{\rho_1 (P_2 + R) + \rho_2 R\} - (E_2 + e) R \rho_1 =$$

$$E_1 \{\rho_1 (\rho_2 + R) + \rho_2 R\} - E_2 R \rho_1$$

$$\rho_1 \{e_1 (\rho_2 + R) - e R\} = - e_1 R \rho_2$$

$$\therefore \rho_1 = \frac{e_1 R \rho_2}{e R - e_1 (\rho_2 + R)}.$$

Having found the value of ρ_1 we can substitute it in the equation

$$E_1 = \frac{E_1 \{\rho_1 (\rho_2 + R) + \rho_2 R\} - E_2 R \rho_1}{R \rho_2}$$

and from this determine E_1

To take a numerical example, suppose the normal E.M.F. of the dynamo is 101 volts, its armature resistance $\cdot 01^{\omega}$. External resistance is 1^{ω} and terminal E.M.F. required is 100 volts, the greatest variation in which is to be 1 volt; the greatest variation in the E.M.F. of the dynamo being 5 volts.

Here $e = 5, e_1 = 1$

$$\therefore \rho_1 = \frac{1 \times 1 \times \cdot 01}{5 \times 1 - 1 \times (\cdot 01 + 1)} = \frac{\cdot 01}{5 - 1 \cdot 01} = \frac{1}{399} = \cdot 0025^{\omega}$$

And

$$E_1 = \frac{100 (\cdot 0025 \times 1 \cdot 01 + \cdot 01) - 101 \times 1 \cdot \times \cdot 0025}{1 \times \cdot 01}$$

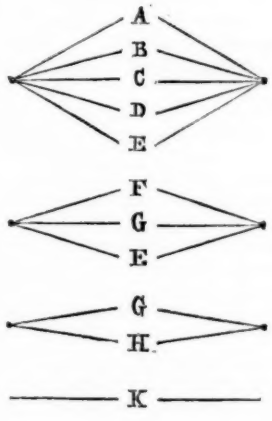
$$= \frac{1 \cdot 2525 - \cdot 2525}{\cdot 01} = 100 \text{ volts.}$$

If there are more than two batteries in arc they can be taken in pairs, finding the E.M.F. and internal resistance of the equivalent battery for each pair; again taking the equivalent batteries in pairs, and so on until at last they are reduced to one battery which will be the equivalent of them all.

For instance, suppose batteries A, B, C, D and E, are in arc. Find the equivalent battery to the two, A and B, let it be F. In the same manner let the equivalent battery to C and D be G.

Now find the equivalent to F and E and let it be H.

Find the equivalent of G and H and let it be K. Then K is the battery equivalent to the batteries A, B, C, D and E in arc.



* It will be seen that e and e_1 may be either positive or negative quantities but must always have the same sign.

ELECTRIC REPEATERS FOR RAILWAY SIGNALS.

REPEATING railway signals mechanically is almost as old as the "signals" themselves; but as difficulty was experienced owing to the distance, electric repeaters were introduced, but were used for those signals only that were out of sight of the signalman, so that for a long period few of these repeaters were brought into use. The late Mr. C. F. Varley once said that it should be looked upon as a golden rule never to do anything electrically unless distance prevented its being done mechanically. This rule has been largely broken through, as repeaters are in many cases used where the signal is only a few yards distant from the signalman, and in some large railway companies, electric signal repeaters are numbered by the thousand. It is not to be wondered at that there should be a variety of ways of repeating signals. Mr. Warwick, the late telegraph superintendent to the Midland Railway, was one of the first in the field; his scheme indicated signal "on" by current and "off" by gravity; other inventors did the reverse of this; which latter course was not on the side of safety, for, in the event of a wire breaking, the repeater would show "on," although the outdoor signal might be "off;" With the former method, however, any electrical failure would show signal "off," although it might be "on," and the worst that could happen would be the unnecessary stopping of a train. It is needless to say that great improvements have been patented for repeating signals, but most of them have been by, either additional wires or additional batteries, or both; and so show signal "on" and signal "off" by current.

Repeating the "arm" is not the only thing that some of the first inventors did, but they also arranged to indicate whether the signal light was "in" or "out."

Most of these schemes that have been from time to time introduced have necessitated :—

Separate wire for "on" } or one wire and separate bat-
" " "off" } teries for "on" and for "off."
" " "in," "out" being indicated by gravity.

The most complete scheme that has come under our notice is the subject of our illustrations, and is the invention of Mr. J. W. Fletcher, chief telegraph superintendent and engineer of the London and North-Western Railway.

By the use of one wire and one battery, he shows signal "on," "signal "off," signal "wrong," and, by the same wire, and bringing into play automatically two additional cells, shows, light "in," light "out."

Some inventors urge that there is an advantage in using a separate battery for "on," and another for "off," inasmuch that, while one battery is at work, the other is at rest, and so recruiting itself; the inventor of the one battery scheme meets this by saying, that it is not a matter of opinion, but a matter of fact, that decidedly one battery is best, and for the simple reason that, where one battery is used, a fault cannot be remedied except by a new or refreshed battery; where two batteries are used the "on" or the "off" battery only may fail, and the signalman begins to regulate his signal wire, not knowing that it is a battery failure; but when one battery is used, and his repeater shows "wrong," no regulation of the signal wire will move the indicator from the "wrong" position, and the signalman knows that it is an electrical and not a mechanical defect.

Figs. 1, 2, 3, 4 represent the repeater in the signal-box, the contact-box or pole changer, the expansion tube, and the battery at the signal-post, respectively. In fig. 1, E is the repeater arm indicating the position of the signal arm, F a disc working in connection with the arm E, showing when the signal is wrong, D a disc showing when the light is "in" or "out." In fig. 2, the outer springs form the earth connection marked H, the two inner are the battery springs, and the stud at the top will be seen to be the line connection, the lever Z places either the positive pole to "earth," and the

negative to "line," or *vice versâ*. The position shown is that in which the springs are all disconnected, and the arm E shows signal "wrong." In fig. 3, the piece A is moved by the expansion in tube T and has small insulating pieces at each end, on which either the spring S^2 or S^1 rest, the current passes by means of the springs S^1 or S^2, through the piece A, to the spring S^3 and S^4, and thence to the contact box, in the normal position of A; that is to say, light "out," the current

FIG. 1.

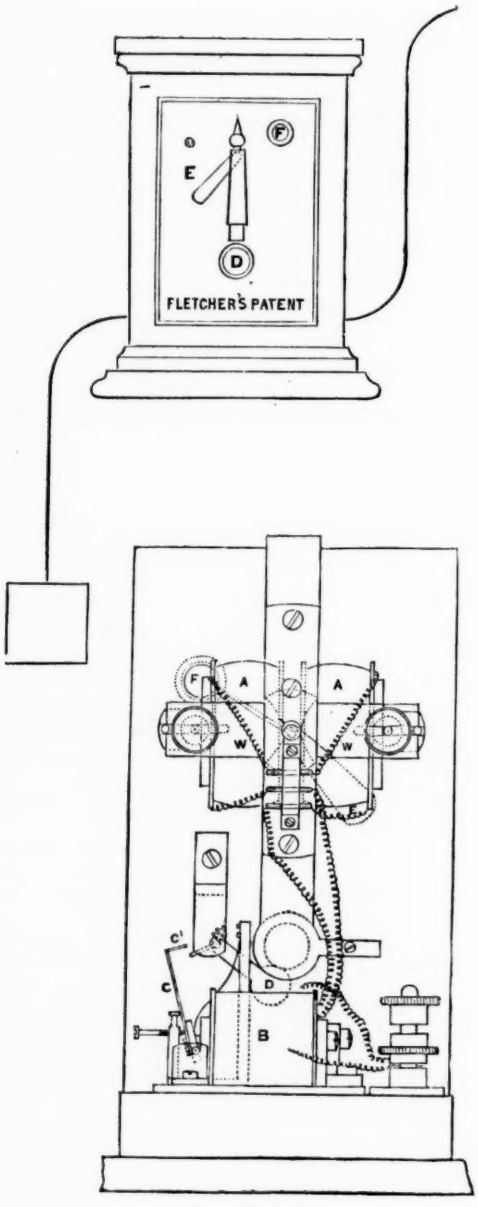


FIG. 5.

passes by means of S^1 through A and S^3 and S^4 to the contact box; thus it will be seen that only half the battery is used to repeat the position of the arm, S^2 resting on the insulating piece; when the light is "in," A is moved by the expansion of T, and the spring S^1 passes on to the insulating piece immediately after S^2 comes on the metal part of A, thus placing the whole battery in circuit and indicating light "in."

Fig. 5 represents the "repeater," in which the coils, A, actuate the arm, E, and disc, F, and coil, B, the armature, C, and its attachment, C^1, which in turn raise the disc, D. It will be seen that the coils B are joined, one on each side of the coils, A, A.

THE EFFECT OF AN ELECTRIC CURRENT ON THE OSCILLATIONS OF SUSPENDED BODIES.*

By N. KOLKIN.

SEVERAL years ago I noticed some peculiarities in the oscillations of suspended bodies. If an oscillation was produced in any direction, from any cause, I frequently

FIG. 2.

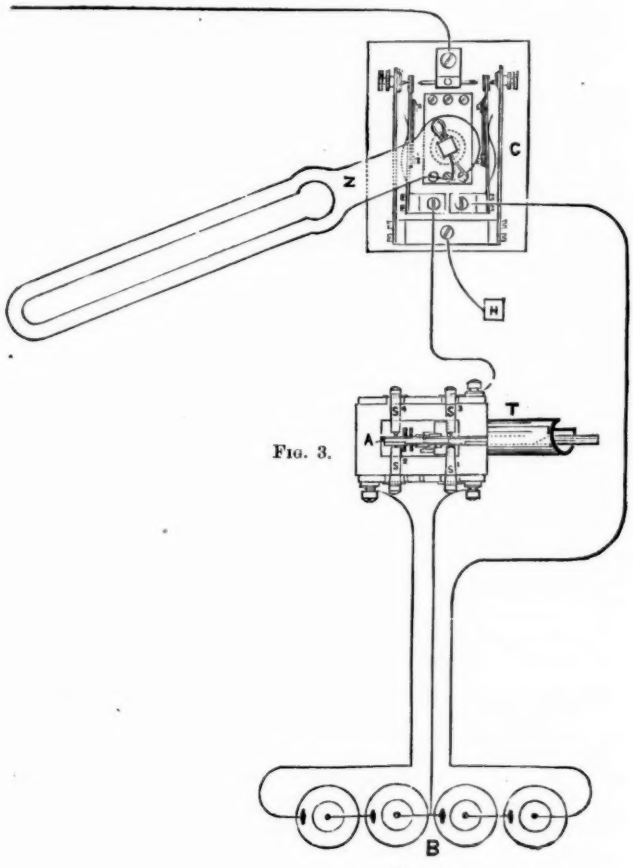


FIG. 3.

FIG. 4.

found that there was a gradual change in direction, until one was reached which was kept with great tenacity. Sometimes there would be changes from oscillation to circulation, and *vice versa*, several times.

These peculiarities have been accounted for in an off-hand way; the causes assigned have been peculiarity of the original impetus given, obstacles on one side of the support, and currents and vortices of air. We may remove these causes, and still we find the same peculiarities.

For experiment, a hole may be bored in the lower side of any horizontal strip of wood that is raised a distance above the ground. A wooden plug, to be inserted in the hole, may be split in two, and the cord or fibre, which carries the suspended body, may be held tightly between the two halves of the plug.

If this pendulum is suspended between two vertical metal plates, respectively of zinc and copper, which are moistened with sulphuric acid, it will always oscillate in the direction of the electric current that passes, through the air, from the zinc to the copper. If the oscillation is at angle with the current, the direction slowly changes. The pendulum should be entirely within the current to be observed.

Electric currents in the atmosphere are indicated in

* Presented to the National Academy of Sciences, Minneapolis, America.

the same way. These generally have the same direction as the wind, commencing and ceasing an hour or so before it. It depends on the length of the pendulum, whether general or local currents are indicated. The Foucault pendulum indicates electric currents and will not always turn the same way. The pendulum is carried farther in that direction in which the current moves.

In no case do we find that an electric current will originate oscillations of a suspended body, but simply change them. It will also magnify the effect of an impetus given to them, when the two forces act in the same direction; for a suspended body will oscillate more easily in the direction of an electric current than in any other.

By means of minute pendulums it is possible to detect the smallest current, and they are the only means by which many mysteries in nature can be investigated. They have been used by the author for several years, both to test the accuracy of their indications and in physical research. The method, however, is very tedious.

When a pendulum is oscillated in damp, foggy, or very cold weather, the oscillations will never change from the original direction. In such states of the atmosphere the pendulum will also come to rest sooner. The air may also be given the same condition by the friction of bodies, but the friction of bodies of opposite character, as wood and metal, neutralises their effect. For such reasons crowds of persons, or only one person, may easily spoil experiments of this kind. It is only in fair weather that these experiments can be carried on undisturbed.

If electricity is an ethereal fluid, that which gives the air the peculiarity spoken of, seems to be an ethereal substance of another consistency; for the power to hold the pendulum may be imparted to the air, over a well-defined region, by the friction of substances, and an electric current will pass through it, as it can be detected where it enters and where it emerges from it.

THE STRANGE HISTORY OF A DYNAMO,

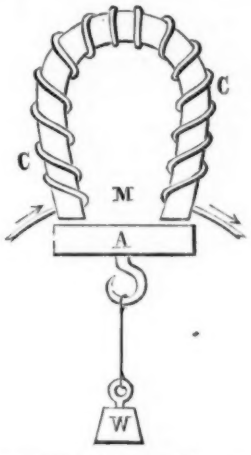
As told by itself to

A. DYNAMICABLE.

[*All rights reserved.*]

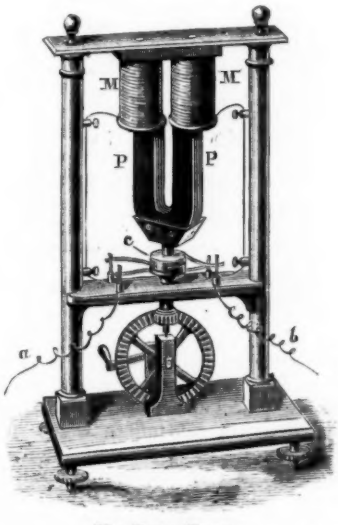
(*Continued from page* 349.)

ONE Pixii is held responsible for my first appearance in the world in such a form as to yield in my turn that which led to my being, viz., an electric current. Tiny, weak, and undeveloped as I then seemed, I was the object of great wonderment, and much curiosity was evinced as to what the future had in store for me. Although I have to carry my memory back to the year 1832, you may rest assured that the portrait which I present to you gives a faithful representation of my poor little self as I then appeared. I cannot now repress a smile at the ridiculous figure I cut, although I was mightily proud and self-satisfied in those days. Time, however, changes all things and nothing more, to my way of thinking, than dynamos. But I must get on with my narrative. You, of course, have not forgotten Arago's discovery, from which we found that a galvanic current passing through a coil of wire surrounding a rod of iron transforms the latter into a powerful magnet, or more precisely speaking, into an *electro-magnet*,—or that a magnet proper, or so-called *permanent* magnet, is a rod or bar of *steel* of any form which has been magnetised and which then *retains* (soft iron does not) its magnetism. Towards the end of the year 1825 one of your countrymen, Sturgeon by name, made a considerable advance on Arago's experiment by making an electro-magnet in a horseshoe form. The improvement does not, on the face of it, look as if much thought had been expended thereon, for it is simply, as you observe, the straight rod of Arago bent into a horseshoe form so as to bring its ends into proximity one with the other. The importance of this arrangement can, however, be scarcely over-rated, for by making use of both ends of the electro-magnet a weight many times heavier may be carried than is possible when one end only is employed. In this sketch, M is the bent iron rod upon



STURGEON'S ELECTRO-MAGNET.

which is wound, in the same direction throughout, the insulated wire, C, through which a strong galvanic current is flowing, say, in the direction of the arrows. Under these conditions the iron rod becomes powerfully magnetic, and, if we bring near to its ends the piece of soft iron, A (generally called an armature or keeper), this will be attracted with great tenacity, and heavy weights, W, may be suspended therefrom. This, bear in mind, is the most simple form of horseshoe electro-magnet, and not exactly of the kind which formed part of me, as you will now perceive. As the production of Pixii, my upper part, or head if I may so term it, was formed of an electro-magnet, M, M, attached to the top of a framework and underneath were my lower extremities, or legs of a permanent magnet, P, P, arranged to rotate with great rapidity by means of a toothed wheel and pinion. Like some neglected infants I was brought up, or, more strictly speaking, turned, by hand, and my energy was displayed not as in the case of the unattended babes to whom I have just alluded, by the strength of my lungs, but in the production of certain physiological effects which I took good care should make themselves felt by those who handled me carelessly or whose touch was directed to an unprotected part.



MY PIXII FORM.

In other words, electric currents were obtained from me of sufficient intensity to produce small sparks and

to give severe shocks to those who came in contact with certain portions of my anatomy, to wit, the wires, *a* and *b*, which you notice hanging from me.

I admit freely it was a shocking beginning, but for that Pixii must be held responsible.

I may add *en passant*, that the intensity of these currents and therefore the effect I produced upon the unwary, depended upon the strength of the magnets and the closeness of their extremities to the ends of the electro-magnets. Retracing my steps for a moment: you have not forgotten what I impressed upon you but a short time since respecting the currents produced in a coil when a magnet is inserted and withdrawn very rapidly. Good! your memory serves you well; the currents were in *opposite* directions.

Now my Pixii form produced these very same currents which, for such purposes as medical applications, answered very well; but to make me of universal service it became necessary that something should be done to enable me to convert these opposite or alternating electrical impulses into *continuous* currents, or those which are said to flow in the same direction as from that more ancient source of electrical energy, the galvanic battery. For such purposes as electro-plating, electro-typing, chemical decomposition, the electrical transmission of power, &c., it became absolutely necessary that I should be able to do all that of which a galvanic cell is capable.

This want was met by the invention of an ingenious device technically called a *commutator*, or, as we may in plain language term it, a current changer. It was then possible to turn the alternating currents which, by virtue of my form, I produced, into those which passed continually in the same direction.

Thanks to Hyppolyte Pixii, therefore, I became the very first exponent of the great Faraday's investigations, and I have naturally cherished a far greater affection for him who first saw what could be made of the germ which he nurtured to such purpose than for the many who changed me little by little into what you behold me now.

I was not, as you may imagine, long left in this primitive form, for a Mr. Saxton came upon the scene, and, taking advantage of my youth and inexperience, so beguiled me that in the end he completely turned my head. After such an admission as this, you will readily understand that I made but a feeble resistance to the liberties which he further took with me and which I hereby disclose to you.

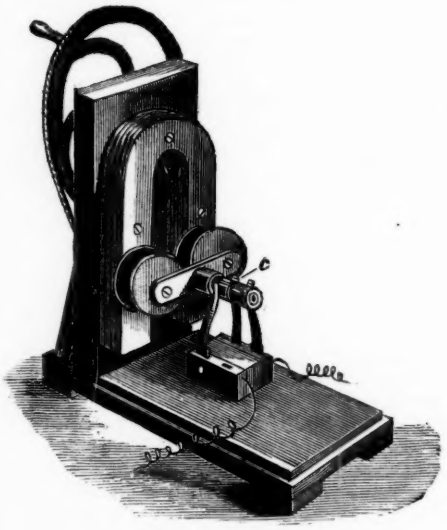
When I state that this gentleman completely turned my head it is only another way of telling you that he reversed the form in which Pixii had modelled me, and made my head—that was—turn in the place of my lower extremities. This, I candidly confess to you, was an advantage, although I did not look upon it as such at the time; for being light headed I did not in this, the second stage of my being, necessitate the expenditure of so much muscular energy to produce the same results as previously. The extent to which I was mutilated by Saxton can thus be easily detected in this new portrait of my early youth.

You may infer therefrom that my original head was placed, not exactly between my legs it is true, but beneath my feet. You think the non-technical reader will be in some perplexity respecting the manner in which the currents produced within me could, by the commutator, be taken from me as it were? Well, I will briefly enter into the details of that part of me which shall make this clear.

Before doing this I will first of all show you my third adaptation, which took place at the hands of a Mr. Clarke, but two years after my birth.

It occurred to this gentleman that I might be made to give varying effects if he constructed the electro-magnet portion of my frame in duplicate; one set coiled with thick and the other with thin wire. He correctly estimated my capacity and was thus enabled to make my performances of a still more astounding character to the scientists of the day. He also altered the positions of my component parts, as you doubtless notice in this sketch.

The commutator which you request me to explain is shown by the letter *c*, as in my Pixii form.



CLARKE'S ADAPTATION.

Too small you think? Well you shall have a commutator enlarged, and in order that you may all the more thoroughly understand my *modus operandi* I will, at the risk of being thought too technical when I have all along professed to be speaking in plain terms, show you precisely how the revolutions of the electro-magnets in front of the permanent magnet gave rise to those alternating currents which it became so desirable to *commutate*.

(*To be continued.*)

DYNAMO-ELECTRIC MACHINES.*

By JOHN HOPKINSON, D.Sc., F.R.S., and EDWARD HOPKINSON, D.Sc.

OMITTING the inductive effects of the current in the armature itself, all the properties of a dynamo machine are most conveniently deduced from a statement of the relation between the magnetic field and the magnetising force required to produce that field. This relation given it is easy to deduce what the result will be in all employments of the machine, also the result of varying the winding of the machine in armature or magnets. The magnetic field may be expressed algebraically as a function of the magnetising force, or more conveniently by a curve ("Proceedings of the Institution of Mechanical Engineers," April, 1879, p. 246). Amongst the empirical formulæ which have been proposed to express the electromotive force of dynamo machines in terms of the currents around the magnets, we may mention that known as Fröhlich's, where $E = \frac{a\,c}{1 + b\,c}$, E being the electromotive force of the machine at a given speed, *c* the exciting current, and *a* and *b* constants. For some machines this hyperbola is said to express observed results fairly accurately. In our experience it does not sufficiently approximate to a straight line in the part of the curve near the origin, and gives too high results for large values of *c*.

One purpose of the present investigation is to give an approximately complete construction of the characteristic curve of a dynamo of given form from the ordinary laws of electro-magnetism and the known properties of iron. Let *n* be the number of convolutions on the magnets, *c* the current round the magnets, l_1 the mean length of the lines of force in the iron of the armature, A_1 the area of section of iron in the armature, l_2 the distance from iron of armature to iron of pole pieces, A_2 the area of the magnetic field in which the wires move corrected for its extension round the edge of the pole pieces, l_3 the total length of the magnet cores, A_3 the area of the magnet cores, l_4 the mean length of lines of force in the yoke connecting the magnet limbs in machines of the type on which we have principally experimented, A_4 the area of section of the yoke, l_5 the mean length of the lines of force in each pole piece, A_5 the mean area of section of pole piece, I the total induction through the armature, when no current passes in the arma-

* Abstract of paper received by the Royal Society, April 6th, 1886.

ture, and ν I the total induction in the magnet cores; and finally let the relation between the magnetic force (a) and induction (α) (*vide* Thomson, "Electrostatics and Magnetism, p. 397, and Maxwell, "Treatise on Electricity and Magnetism," vol. ii., p. 24) be represented by the equation $\alpha = f(a)$, then the characteristic curve is—

$$4\pi n c = l_1 f\left(\frac{\mathrm{I}}{A_1}\right) + 2 l_2 \frac{\mathrm{I}}{A_2} + l_3 f\left(\frac{\nu \mathrm{I}}{A_3}\right) + l_4 f\left(\frac{\nu \mathrm{I}}{A_4}\right) + 2 l_5 f\left(\frac{\mathrm{I}_5}{A_5}\right)$$

If the relation between a and α be given in the form of a curve, this formula indicates at once a perfectly simple graphical construction for the characteristic. Taking the curve of magnetisation determined by one of us for wrought iron, and constructing a characteristic in this way, we have obtained a theoretical curve which agrees over a long range with the actual results of observation on a dynamo machine more closely than any empirical formula with which we are acquainted.

To determine ν, a wire was taken once round the middle of one magnet and connected to a ballistic galvanometer, a known current was then either suddenly passed round the magnets or short circuited, the elongation of the galvanometer being noted. A similar observation was made with the same current, the galvanometer being connected to a single convolution of the armature in the plane of commutation. The ratio of the two elongations is the value of ν.

The distribution of the waste field $(\nu - 1)$ I was roughly ascertained in a similar manner.

The currents in the fixed coils round the magnets are not the only magnetising forces applied in a dynamo machine. The currents in the moving coils of the armature have also their effect upon the resultant field. In well-constructed machines the effect of the latter is reduced to a minimum, but it can be by no means neglected. This introduces a second independent variable, viz., c, the current in the armature. The effect of the current in the armature depends upon the lead given to the brushes. Denote this by λ, which we may also regard as an independent variable, as it is subject to arbitrary adjustment.

If $\mathrm{I} = \mathrm{F}(4\pi n c)$ be the characteristic curve when no current passes through the armature, then

$$\mathrm{I} + \frac{\nu - 1}{\nu} 4\lambda m c \frac{A_2}{l_2} = \mathrm{F}\left(4\pi n c - \frac{4\lambda m c}{\nu}\right),$$

where m is the number of convolutions in the armature. Here we omit the comparatively unimportant portion of the magnetic force in the core of the armature and the pole pieces. From this formula it is not difficult to deduce a geometrical construction for the characteristic surface (*vide* "Practical Applications of Electricity," Lectures delivered at the Institute of Civil Engineers, 1882–83, p. 98). The equation may be thus expressed in words, if λ be such that the coils at commutation embrace the whole, or nearly the whole, induction. The effect of the current in the armature upon the difference of potential between the brushes of any machine, is the same as that of an addition to the resistance of the armature proportional to the lead of the brushes, and to the ratio of the waste field to the total field, combined with that of taking the main current $\frac{m\lambda}{\nu\pi}$ times round magnets in a direction opposite to the current, c. Many consequences can be deduced, of which we may notice the following:—In a series-wound dynamo c is equal to c, and if c be increased beyond a certain point, I must attain a maximum and then diminish; this has been frequently observed. We now see that it depends upon the existence of a waste field. Secondly, let the coils of the magnets be entirely disconnected, and let λ be the negative: if the armature be short circuited through a small resistance and be run at a sufficient speed, a large current may be produced in the armature. This latter deduction we have verified by direct experiment.

The efficiency of the type of dynamo machine upon which the experiments before indicated have been made, has been accurately determined by the device of coupling two similar machines, both mechanically and electrically, so that one should act as a generator of electricity, driving the other electrically, whilst the latter acted as a motor driving the former mechanically; the loss of power required to keep the whole combination in movement being determined by direct dynamometric measurement, and the power passing electrically from the one machine to the other being measured by ordinary electrical appliances.

The whole of the experiments were carried out at the works of Messrs. Mather and Platt, to whom we are indebted for the exceptional opportunities we have enjoyed of putting theoretical conclusions to the test of experiment on an engineering scale.

East of Scotland Engineering Association.—The members of this association met recently at the Waverley Station, and were first shown over the electric installation there, under the guidance of Mr. Thomas Carswell, who explained the arrangement and methods employed. This gentleman afterwards read a paper entitled, "Some methods used in practical electric lighting," in which he described several of the different systems used by the various electric companies. After considerable discussion, a hearty vote of thanks was awarded to Mr. Carswell.

REVIEW.

Theoretical-Practical Manual for the Electrician. (Manuale Theorico-pratico dell' Elettricista.) Milan: Office of the *Elettricita*.

This work, which is illustrated with 86 woodcuts, is due to several authors. The preface is from the pen of E. Bignami. P. Meardi contributes the section on lightning conductors; T. Bonadiman expounds the galvano-plastic art; A. Martinelli discusses the domestic applications of electricity, such as bells and other indicators and alarms; Dr. A. Pellini describes telephones and microphones; P. Meardi gives an account of the electric light; and Prof. Gandini discusses accumulators. All these various applications of electric science are dealt with very clearly, and as fully as is compatible with the size of the book. The object of the various authors is plainly more practical than theoretical, and they evidently pre-suppose in their readers an acquaintance with the general principles of the science. Towards the conclusion of the section on galvano-plastie we find a curious passage bearing on the question of lighting, private and public. Signor Bonadiman writes:—"The preparation of magnesium at a relatively low price will have a great industrial importance, especially for lighting purposes. According to Roscoe, 72 grms. of magnesium give as much light as 10 kilos. of stearine candles. At present the price of magnesium is still too high (450 lire per kilo. = about £8 11s. per lb.), and its light is still much too dear as compared with that of candles. But if it can be prepared at the twentieth of its present figure, which will be obtained in time, the magnesium light will become very economical and advantageous. Electricity will then be seen co-operating with its own peculiar action in dethroning itself." To this we may add that the magnesium light, in point of purity and whiteness, is the best substitute for daylight yet devised, and that, according to recent reports, a very great step towards the necessary reduction in cost has just been effected. It will be a curious and unexpected result if electricity should be found to give more light when employed in the preparation of magnesium than in direct illumination. The illustrations of this manual are judiciously selected and well executed.

NOTES.

The Electric Lighting Bills.—In the House of Lords, on Thursday, the 15th inst., the Earl of Camperdown presented a petition from the Vestry of the Hamlet of Mile-end Old Town against alteration of Section 27 of the Electric Lighting Act, 1882. The Duke of Abercorn, at the same time, presented a petition from the Society for the Encouragement of Arts against the Government Bill for the amendment of the Electric Lighting Act of 1882.

The Colchester Electric Lighting.—Attempts have been made to form a new company, locally, to continue the electric lighting business entered into at Colchester by the now dissolving South-Eastern Brush Electric Light Company, and a recent meeting of the consumers was held to discuss the matter. Mr. E. Thompson Smith advocated the formation of a new company, and asked whether the consumers were willing that the lighting should be stopped for a period pending such alterations and additions as might, under the new system, be found necessary. It seems, however, that an undertaking had been entered into by the Electric Lighting Company to return 75 per cent. of the value of the fittings, should the lighting cease, and this 75 per cent. the consumers are anxious to obtain, so they declined to enter upon any new scheme until they had quite done with the liquidator of the South-Eastern Brush Company.

Incandescent Lamps in Mines.—An underground engine-room and other deep workings in one of the Ecton mines, Staffordshire, have been supplied with electric lamps during the present month, which have effected considerable saving as against oil lamps and candles. Lamps of 20 and 50 candle-power are used, and the wires run on insulators fastened into the rock. The dynamo has been manufactured by Messrs. Holmes and Co., and is a new type of compound self-regulating machine, with capacity of 30 ampères at 60 volts. The installation has been carried out by Mr. J. H. Bowman, electric engineer, of Alport Bakewell, and is giving great satisfaction.

Electric Lighting of the Tilbury Docks.—The new docks of the East and West India Dock Company at Tilbury, which were opened last Saturday, contain, perhaps, the largest installation of electric lighting in the world. In the out-door portion of the docks 80 arc lamps of 3,000 C.P. each are employed, many of them being placed on posts 50 feet high. To prevent shadows being thrown by the lamps, a new suspending arrangement has been employed, the invention of the contractors, Messrs. R. E. Crompton and Co., whereby the lamp is placed immediately over the top of the pole. Incandescent lamps, 1,362 in number, are used in the various sorting and storing sheds, the general offices, the canteen, and elsewhere. They are of from 16 to 22 C.P. Portable lights are also available in the sorting sheds, and groups of lamps are supplied for placing on steamers when unloading. Five engines and boilers are employed, and they are capable of a maximum output of 500 effective H.P. There are 16 dynamos of the Crompton type, which is now well known. They are driven from counter-shafting by belts of the quality known as the "Shortlap Hoyt," supplied by Messrs. Balderston, and great care has been taken to so arrange the whole plant as to reduce any part to a minimum risk from accident or breakdown. The disposition of the lights over the docks has been made in such a way as to illuminate brilliantly those parts that are most likely to be in use at any particular time. The quays and railway sidings are thus well provided for, and large lanterns are fixed in positions most suitable for unloading, &c. The large hotel which has been erected just outside the docks has also been fitted throughout with incandescent lamps. The whole of the lights in use in the docks can be controlled by the engineer in charge, as the main switch-boards are placed in convenient positions in the engine-house. The arrangement of these switch-boards with cut-outs and other appliances attached are of the most elaborate nature.

Electric Lighting of the Exeter Lunatic Asylum.—The Consolidated Electric Company, which last year obtained the contract for lighting the new lunatic asylum just erected for the Exeter Corporation, having gone into liquidation, it has become necessary for the Corporation to "make other arrangements." The Asylum Committee, however, still believes that the "electric light, from a proper installation, is brilliant, reliable, perfectly safe, and under control," for it has recommended that the tender of Messrs. Woodhouse and Rawson, which was next in amount to that of the Consolidated Company, should now be accepted. Messrs. Woodhouse and Rawson have offered to take over the contract of the defunct company, with slight alterations, and, although several councillors spoke somewhat strongly against the electric light and suggested that gas should be employed, their offer has been accepted. The terms are £1,945, and £210 per annum to maintain the whole of the plant in good working order for seven years.

Military Use of the Telephone.—We understand that, in connection with the manœuvres which are to be carried out on Easter Monday and two or three preceding days in the vicinity of Portsmouth, the telephone will play a rather important part. The different forts which are to be garrisoned by the defending force, will be connected by wire, so that the approach of the enemy and other messages of an important description, may be promptly circulated. The necessary apparatus is to be fitted by the Western Counties and South Wales Telephone Company.

Telephone Experiments.—The efficiency of the telephone for moderate distance communication was put to the test at Portsmouth last week, in connection with a lecture delivered by Mr. J. H. Sandy, the local manager of the Western Counties and South Wales Telephone Company. By the permission of Mr. Goldston, telegraph superintendent to the railway company, Mr. Sandy was permitted to make use of the railway telegraph wires. The wires from the Protestant Hall were connected at the Portsmouth Town Railway Station, and at Southampton, twenty-four miles distant, the telephone agent was in attendance to speak through. In order that the audience might have an opportunity of judging for themselves, extra receivers were placed in the hands of several of their number, who expressed themselves thoroughly satisfied with the experiment.

The Meucci Telephone.—A company has been formed, called the Citizens' Telephone of Newark, N.J., for the purpose of doing a general telephone exchange business, and it is said that the construction of lines will be begun as soon as 300 subscribers have been obtained. It is said that 100 of these were secured in one day. The new company claims that the rentals will be 30 per cent. less than those charged by the Bell Telephone Company. The Meucci telephone will, it is said, be used, but not, we presume, the original form of that instrument.

The Telephone on Board Ship.—Capt. J. D. Randall, master of the steamer *Enquirer*, of Memphis, Tenn., claims to be the first to employ the telephone on board of a steamboat. His steamer, when at the landing, is connected with the exchange, and the arrangement is found to be very convenient. The telephone is "grounded" in water and works very well. As it is not possible for the river steamers to land at the city wharf every day in the same place, a wire is strung up and down the river, and from each pole a loose wire hangs down, to which connection is made. From that it runs to the boom of the stage rigger, at the bottom of which a wire is connected to the telephone in the office of the steamer.

Our correspondent in the North of England who recently gave us some information respecting telephones on board a steamer, will probably recognise the difference between the installation of which he spoke and that mentioned here, where communication with the shore was the great point aimed at.

Cable Rates.—It is announced that the Eastern Telegraph Company will reduce rates to several stations on July 1st.

Atlantic Cable Broken.—A telegram from New York announces a fracture in the French cable about 220 miles from Duxbury.

Atlantic Cable Competition.—A further reduction in the Atlantic cable rates is announced. The Western Union Telegraph Company informs us that on and after the 5th May next the rate for telegrams to New York and most of the principal telegraph stations in North America will be reduced to sixpence per word; and the Direct United States Cable Company also sends a communication to the same effect, with the additional information that special arrangements may be made for the transmission of Press messages at threepence per word. The other companies which have a share in the "pool" arrangement have also reduced to 6d. per word. We would suggest to the Commercial Cable Company that it may possibly be the wiser plan to maintain its present rate; or, at all events, to devote one cable to messages at an increased charge, such messages to have precedence of all other matter.

SS. "Buccaneer."—Early in the month this ship arrived at her moorings off the works of the India Rubber and Gutta Percha Company at Silvertown after a cruise of nearly six months duration. The ship is not only fitted with the machinery necessary for cable work, her light draught making her very handy for landing shore ends on a shoal coast, and for river work; but she also has every appliance for ocean research as the work she has lately been engaged in had for its object, besides the selection of the best ground for cable laying, the solution of many problems connected with the bed of the Atlantic on the African side. We understand that the soundings and observations carried out under the direction of Mr. J. T. Buchanan, and which extend over a large tract of hitherto unexplored ocean, have resulted in the acquirement of most interesting additions to the science of marine biology and to the knowledge of currents along the African coast, more especially with regard to the equatorial current. Mr. Buchanan has been assisted by Mr. J. Rattray, naturalist, and some of the Silvertown staff, including an analytical chemist; the actual work, the preparation of specimens, and the recording observations and results, necessitating a comparatively numerous body of assistants. The results which most interest the West African Telegraph Company (under contract with whom the Silvertown Company is carrying out the work of establishing telegraphic communication along the African coast) are those which relate to the soundings. These show throughout the whole route to be followed by the cables, a splendid bottom of soft mud and globugerina ooze, with the exception of two places where rocky ground is met with, but which can be easily avoided owing to the information now acquired. We trust that Mr. Buchanan will publish the results of his observations, which must be of special interest with regard to the Gulf of Guinea, the ocean bed in the neighbourhood of the islands of Principe and St. Thomé, the debouchure of the Congo, and the researches on the equatorial current. The necessity of carefully selecting men, and also of carefully looking after them, on an expedition of this nature, where the climate is so adverse, was never more fully demonstrated, and it is due to the fact that officers and men were chosen not only with regard to their abilities, but also with consideration as to their physique (the weaker ones being weeded out and transferred to the other ships while on the coast), that no sickness was experienced during the cruise, and it must be remembered that the work of sounding, taking serial temperatures, and observing the force and direction of currents involves no slight amount of labour and exposure.

The "Naniwa Kan."—Mr. A. A. Campbell Swinton writes to us to point out several inaccuracies in our paragraph concerning this cruiser which appeared in our issue of the 16th inst. The steering gear is hydraulic, not electrical, as stated. There are no less than four search light projectors, two being on the forward and two on the after bridge. The engine room telegraphs are of the ordinary mechanical type. The guns, as well as the torpedo tubes, are fitted with electric firing gear, so that by pressing a key in the conning tower a broadside of five guns can be simultaneously discharged. The whole of the lighting and other electrical installations have been carried out by the electrical department of Messrs. Sir W. G. Armstrong, Mitchell & Co., who built and fitted out this most redoubtable vessel.

Progress in Electrical Tramcars.—We hear on good authority that Mr. Reckenzaun has received definite orders for no less than twenty 1-horse cars for German tramways. We trust that this success abroad will give increased confidence in electric locomotion in our country.

Notice of Removal.—The Western Electric Company notifies a removal to new premises at 79, Coleman Street, E.C.

Electricity in Shipbuilding Yards.—Messrs. Sir W. G. Armstrong, Mitchell & Co., of Newcastle-on-Tyne, the famous manufacturers of ordnance and builders of ships of war, have an electrical department included in their vast establishment. Among other works, they have recently completed an extensive installation of incandescent lamps in their drawing offices, above 200 lamps being employed. They have also lately fitted up two large Japanese cruisers with incandescent and search arc lamps, and have at present in hand a similar and very extensive installation on a large Chilian ironclad. They have, moreover, adopted electric arc lighting in their new steel works and metal foundry, and also in their recently finished Elswick shipyard, and in the latter make extensive use of temporary installations of incandescent lamps for the interior illumination of war ships in course of construction. Electricity is also employed in connection with the chronographs used for determining the velocity of the shot fired at their proof ranges, and also for the measurement of the temperature of some of their furnaces. There is a complete system of telephonic and telegraphic communication between the various departments, there being no less than 21 separate sets of instruments in connection with the establishment. When it is remembered that the Elswick part of their works is in itself over a mile in length, the advantages of the above becomes immediately apparent.

Newspaper Science.—We read in the *Swansea Cambrian* of the 9th inst., that "there is a defect in electric lighting which the researches of specialists and their experiments have failed to overcome. *That is the vacum (sic) which every now and then occurs in even the most powerful systems of incandescent lighting, causing a constant failure in the steadiness of the gleam.*"

Railway Benevolent Institution.—We have been requested to state that the annual dinner in connection with this institution will take place at the Freemasons' Tavern, London, on Wednesday evening, the 12th May, under the presidency of John Dent Dent, Esq., Chairman of the North Eastern Railway Company. The institution has been established to provide for the necessitous members, orphans, children, and widows of the railway officers and servants in the United Kingdom. We understand that a special fund in connection with Mr. Dent's presidency is being raised, and that it has been arranged that subscriptions may be addressed to Mr. Dent, at the company's office, York.

The City and Electric Lighting.—At last Tuesday's meeting of the Commissioners of Sewers, the Remembrancer (Mr. G. P. Goldney) reported that three electric lighting Bills had been introduced in the House of Lords. He thought it necessary that the Commission should be in a position to tender evidence, as he imagined they had a larger experience in the electric lighting of towns than any other authority. He had, in fact, been requested by one of the peers to make arrangements for evidence to be given by the Commission. He did not propose that they should embark on a costly inquiry, but it was quite possible the Engineer's opinion might be desired by the committee. He had drawn up a short petition to enable them to bring forward witnesses, which he asked the Court to sign. The petition was signed accordingly.

The Edison-Bergmann Transmitter.—A correspondent writes to us respecting this apparatus which was illustrated in our last:—"Be good enough to show the connections in the different parts of the transmitter and show how the centre of the spindle can regulate the screw, rigidly supported and bedded in the front of the case, for I am puzzled." As we remarked in our "Notes" last week, p. 354, our illustrations were taken from an American contemporary; we cannot supply any further particulars.

The Electric Lighting Bills.—The Select Committee of the House of Lords upon the three electric lighting Bills is composed of the Earl of Camperdown (chairman), Earl Cowper, the Earl of Crawford and Balcarres, Viscount Bury, Lord Balfour of Burleigh, Lord Methuen, Lord Houghton, Lord Rayleigh, and Lord Lingen. The Committee will commence its inquiry on May 10th.

Telephonic "At Homes."—During the past week the Northern District Telephone Company has had an exceptionally busy time, the trunk lines between Middlesborough and Stockton, and Stockton and Hartlepool having been opened. These events were celebrated by telephonic "at homes," given at the three towns, namely, at Middlesborough on Wednesday, Stockton on Thursday, and Hartlepool on Friday. The invitations issued by Mr. Clay, the manager of the company, were taken advantage of to a large extent, as shown by the large and fashionable audience on each evening. The Theatre Royal at Middlesborough being connected, the performances given by the Royal English Opera Company were distinctly heard and much appreciated each evening; and, when it is stated that every word and note of music could be heard at Hartlepool (a distance of rather over 19 miles) just as plainly as at the company's exchange at Middlesborough, further comment upon the excellent way in which the line has been erected is unnecessary.

Telephonic Rates.—The Glasgow corn merchants who are connected with the exchange of the National Telephone Company, have resolved to cease their subscriptions at the close of their existing contracts with the company, unless they have an undertaking that the annual charge shall not exceed £15.

Fire at the Liverpool Telephone Exchange.—One day last week a fire occurred in the telephone exchange at Liverpool, resulting in the almost total destruction of the plant. Considerable skill and energy have since been displayed by the officials in repairing the damage caused by the fire. In five days afterwards, all the complicated arrangements were again got into working order. Upwards of 20 miles length of wire had been destroyed. 1,800 wires had to be cut away, having been soldered together by the intense heat, and much difficulty was experienced in finding out the owners of them. The electrician had 5,000 sections to arrange, and 3,000 of them were soldered together as above stated. Mr. W. A. Sharp, the electrician, and Mr. Rowe, the engineer, have earned the thanks of the subscribers and the company for the energy they displayed in so rapidly repairing the damage.

Telephone Exchanges.—The National Telephone Company has decided to establish an exchange in Dunfermline, giving communication with Glasgow, Alloa, Stirling, Falkirk, Dundee and Kirkcaldy.

Telephone Extension to Greenock.—The building of the telephone line from Glasgow to Port Glasgow and Greenock makes good progress and will shortly be opened for traffic. The new line will give a more extended service to the subscribers at Greenock and Port Glasgow, and will also enable the National Telephone Company to discontinue the renting of the two post office wires between Glasgow and Greenock.

The Edinburgh Exhibition.—The electric railway is to be laid down in the northern portion of the grounds, and will run under the line of trees between the east and west entrances. The North Metropolitan Tramways Company, London, will give the use, free of charge, of two of its finest cars: the motive power will be supplied by one of Marshall's engines; and the electricity will be provided by King, Brown & Co.

Trials were made on Monday afternoon and evening with the Thomson-Houston electric light in the permanent building of the International Exhibition at Edinburgh. The installation is divided over three circuits—supplied by different dynamo machines—so that in the event of there being a mishap in any of the circuits the other two may remain intact. Circuit after circuit was tried, and success followed success. Lord Dean of Guild Gowans, chairman of the Executive Council, as well as several members of the council, were present, and all of them testified to the success of the system, which, if exception be made of an installation in Glasgow, is new to Scotland. Besides the permanent building, several of the courts and part of the pleasure grounds will be lighted by the Thomson-Houston Company.

The first trial of the electric light in section D of the International Exhibition, Edinburgh, was made on Thursday week by the Anglo-American Brush Electric Light Corporation, in the presence of Mr. Carey, the engineer, Mr. Bryson, who has the superintendence of the electric lighting, and others, and proved highly satisfactory.

Our Correspondence Columns.—From the date of our present issue to that of our next the Easter holidays will intervene. Bearing this in mind, we shall be glad if our correspondents will be so good as to send their communications to us by Tuesday morning, so as to ensure insertion next week. We have several letters which we are compelled to hold over, one being from Messrs. R. E. Crompton & Co., in reply to our editorial comments on the tests made with one of the firm's dynamos.

The Shooting of an Electrician.—A despatch from Boston, of April 3rd, says:—"Henry K. Goodwin, the inventor, whose trial at Salem, a few months ago, for the shooting of Albert D. Swan, of the Lawrence Telephone Company, is to receive a life sentence for murder in the second degree." Our readers may remember that we notified the crime at the time of its occurrence.

Restoration of Magnetism by Heat.—Writing to the *Scientific American*, Mr. Chas. H. Roberts says:—"To heat a magnet to a red heat has long been known to destroy its magnetism; but from a recent experiment of mine with two sound magnets that have from want of care lost nearly all their magnetism, I fully restored them by rubbing a red hot iron, ¼ inch, over them until it had become quite cool. The magnets are better now than when new. This experiment was prompted in my desire to prove magnetism bears to heat as close a relation as electricity. Thus we hope soon to be able to make a clearer demonstration."

Another Death from Electricity.—A short time ago, a man, named Coyle, was killed in America whilst making an electric light wire connection in front of a shoe store. The coroner's jury found that death was caused by the carelessness of the deceased.

A Telegraphist Killed at Clovelly.—Last Friday afternoon Mr. Knight, a clerk in the Central Telegraph Office, London, was walking with a friend along the cliffs near the romantic Devonshire village of Clovelly, when he attempted to reach some object on the edge of the cliffs, and fell over. He was picked up 100 feet below. His death must have been instantaneous. He arrived at Clovelly on the previous day to spend his Easter holidays.

To our Readers.—It may interest our subscribers and others to know that a very handy reading case has been prepared, in which the whole of the half year's numbers of the ELECTRICAL REVIEW can be filed until the volume is ready for binding. Particulars may be gathered from advertisement on page 10 facing "leader."

Still Another Telephone.—The following telegram from Youngstown, Ohio, appeared in the Chicago papers under date of March 30th :—"A practical test of the new telephone transmitter of the Rose Electric Company was made yesterday under conditions that demonstrate beyond a doubt its superiority over the Bell instrument now in common use. For some time the inventor, Lucien C. Rose, has been secretly at work, and recently the Inventors' Aid Association of this city undertook to assist him. Under its direction application has been made for a patent, and pending the consideration of the case the practical tests referred to were made. The transmitter and receiver resemble in outward appearance those of the Bell instrument, but within there is a difference known only to the inventor. The experiment was successful in every particular, conversation being carried on with perfect ease over the immense length of wire. At no time was it necessary to raise the voice above the pitch used in common conversation. A similar experiment was tried a few weeks ago, when a circuit of 960 miles was used, and this also proved successful. The company is now getting ready for a more thorough test."

A Victory for the Bell Company.—A dispatch of April 5th, from Philadelphia, says :—"In the United States Circuit Court, before Judges McKennan and Butler, argument was to-day heard upon the petition filed by counsel for the Clay Commercial Telephone Company, which asked to have annulled the restraining order issued in the suit of the Bell telephone Company against the defendants. The prayer of the petition was dismissed, and the counsel for the Bell Company was asked by the Court to prepare a final decree in favour of his client and to submit it to the Court to-morrow, so that the appeal of the case to the Supreme Court of the United States could be expedited."

Telephone Exchanges in Western Australia.—According to the *West Australian* of March 8th, the colony in which that journal circulates is putting forth big efforts to make up the distance she has lagged behind her sister colonies in the matters of telegraph communications and railway facilities, and is also now determined not to be behind in making use of the telephone. The Government was taking active steps towards establishing telephone exchanges in Perth and Fremantle. The services of Mr. William J. Hancock, A.S.T.E., of Dublin, had been secured as superintendent of telephones, and that gentleman arrived in Perth about a month before the date given above to commence his duties. Mr. Hancock has had considerable experience in the working of telephones in connection with the Dublin Exchange, which has about 900 subscribers, who use it to the extent of about 7,000 messages per diem. Since his arrival in Perth Mr. Hancock has superintended the construction of telephonic communication between Government House and the office of the Colonial Secretary. He is now making arrangements for the organising of an exchange in Perth and another in Fremantle. In course of time it is intended that a couple of trunk lines shall be run between Fremantle and Perth, so that the subscribers in the two towns may be able to converse with each other as occasion requires. It had not been decided what should be the rent to subscribers, but should there be a fair number of them—say a hundred—in each town, it would probably, our informant states, be fixed at the low sum of £16. The telephone that will most likely be employed is the Bell and Blake magneto instrument.

Self-Induction Experiments.—Mr. Sydney F. Shelbourne, of New York, writes to the *Electrical World* respecting the researches on self-induction which Prof. Hughes has just made public: "The resulting facts made public by him illustrate one thing pretty clearly. It is the difference of spirit and motive with which scientific experimenters in England and other parts of Europe undertake their work as compared with those of the United States. Here it is general practical utility and the endeavour to make the subject pay through the Patent Office. There it is more largely the amateur spirit which partakes of true science, looking mainly to the general reward of reputation, honour, and philosophic recognition. I am sorry to admit that the comparison touches myself as well as other Americans, for no sooner did I see your first editorial notice of Prof. Hughes's address and the experiments he describes, than I immediately turned among my samples to find an old model of a conductor which I had prepared in the autumn of 1883 for the purpose of urging its adoption upon the Postal Telegraph Company, then desiring to lay in Washington, D. C., underground conductors, embracing some heavy ones to be used for their automatic telegraphy, and in which they desired to avoid as much as possible the effects of induction. I had reasoned out theoretically the same conclusions arrived at by Prof. Hughes as to the advantage of dividing the current between a number of parallel conductors, separated from each other in whole or in part, except at the ends, and used as one conductor. The conducting core of my model was composed as follows : A copper wire lightly insulated with winding of paraffined cotton formed the centre ; around this was placed four strands of bare copper wire of the same size as the centre wire, No. 18, Am. G. Each strand was made of two wires twisted together. It will be seen that these four strands did not fully occupy all the space around the centre insulated wire so as to touch each other laterally at every point, but that the random contacts between them will be at uncertain intervals, and that a strand of two wires always leave spaces or depressions at the steps of the twists which would largely separate the wires of any two strands even though in general contact, side by side. With such a conductor, composed, as in this case, of nine wires, and then insulated as a whole, I reasoned that I could accomplish the results now so beautifully declared by the experiments of Prof. Hughes. Unfortunately for my theories and propositions, which were urged before Mr. E. A. Leslie, then one of the electricians of the Postal Company, the appreciation was not cordial or satisfactory to me, and the Postal Company did not care to order any of my conductors for their Washington line, so that my model was returned to the pile of samples in my office and dismissed from my thought until the announcement of Prof. Hughes's experiments."

Government or Private Control.—A recent issue of the New York *Electrical World* contains the following : "Our esteemed London contemporary, the ELECTRICAL REVIEW, makes a warm and eloquent defence of English originality and inventiveness in the electrical field, the occasion of its remarks being a recent little note of ours on the remarkable growth of telegraphy and telephony during the last sixteen years in this country, where electrical applications are unchecked by governmental interference or monopoly. The fact is, as we readily and gladly admit, that England is well to the front in all electrical invention and enterprise, and has a most honourable and enviable record. But we think that she has nevertheless suffered greatly from having her telegraph and telephone service in governmental hands. This opinion, too, is not held solely in America, neither is it in any way disparaging to the many able officials who are to be found carrying out efficiently and with intelligence the heavy work of their respective departments."

Science in Germany.—The Berlin correspondent of the *Standard* says :—"Dr. Werner Siemens has presented to the Government a sum of 500,000 marks (£25,000) to establish an institute for the carrying on of experiments in natural science."

NEW COMPANIES REGISTERED.

Shipping Appliances Company, Limited.—Capital, £10,000, in £10 shares. Object: To purchase the business of supplying signalling apparatus and other shipping appliances belonging to Mr. John Sachverall Gisborne, of 66, Finsbury Pavement, the purchase to include the letters patent No. 311, of 1885, for electrical signalling apparatus. Signatories: R. Bourne Atherley, Wallington, Surrey, 25 shares; H. T. Hanson, 11, Old Broad Street, 25 shares; J. Gibb, 2, Blackheath Rise, 10 shares; W. T. H. Radford, 2, Fenchurch Avenue, 5 shares; W. T. Lockhart, C.E., 7, Fenchurch Street, 10 shares; F. G. Arbuthnot, 66, Finsbury Pavement, 10 shares; F. Tate, 7, Fenchurch Street, 5 shares. Registered on the 16th inst. without articles of association by Messrs. Waterlow, Bros., and Layton, Birchin Lane, Cornhill.

Leslie Liardet, Limited.—Capital, £8,000 in £10 shares. Objects: To manufacture mechanical, electrical, or other gear used in connection with ships, boats, railways, wharves, warehouses, &c.; and, for the sum of £70 cash and the issue of 793 fully paid shares to purchase the patents of Liardet's disengaging hooks (No. 597, dated 27th September, 1883), and of Liardet's improvements in rudders and rudder fittings (provisional protection No. 11,196, dated 21st September, 1885). Signatories (with one share each): H. W. Royle, Cricklewood; A. C. Baber, Broadstairs; J. W. Postlethwaite, 7, Old Burlington Street; E. Samson, 1, Lincoln's Inn Fields; R. Warner, 10, Priory Road, Kilburn; J. Banks, 58, The Grove, Gamberwell; G. E. Baker, 6, Guildhall Chambers. The signatories are to appoint the first directors; qualification, 20 shares; remuneration, £200 per annum whenever the profits admit the payment of £6 per cent. per annum dividend. Registered 17th inst. by Mr. E. Samson, 3, Gracechurch Street.

Miners' Electric Safety Lamp Company, Limited.—Capital, £100,000 in £1 shares. Objects: To purchase from Benjamin Nicholson, of 57, Coleman Street, the right to use for mining purposes certain patent rights granted for improvements in batteries for generating electricity, and for telegraphic, telephonic, and other purposes. Signatories (with one share each), S. C. Woodley, 5, Montern Road, Forest Hill; F. J. King, Northumberland Park, Tottenham; T. Ford, 1, Milton Villas, West Green Road, Tottenham; G. W. Cook, 3, Swan Buildings, Moorgate Street; A. E. A. Nicholson, The Torrs, South Norwood; S. Innes, 94, Manor Street, Clapham. Registered, 20th inst., by Messrs. Burns and Berridge, 9 and 10, Pancras Lane.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

National Company for the Distribution of Electricity by Secondary Generators, Limited.—The annual return of this company made up to the 1st inst. was filed on the 14th inst. The nominal capital is £500,000 divided into 3,000 preferred and 47,000 ordinary shares of £10 each. 2,114 preference and £20,000 ordinary shares have been allotted, and the full amount has been called thereon. The calls paid amount to £11,140, and the sum of £210,000 is considered as paid upon 1,000 preferred and 20,000 ordinary shares.

Swan Electric Light Company, Limited.—The annual return of this company made up to the 16th May, 1885, was filed on the 14th inst. The nominal capital is £100,000 in £10 shares. The whole of the shares are allotted, and £37,500 has been received on account of calls; 2,500 shares have been allotted to Mr. Joseph Wilson Swan as fully paid, the paid up capital thus amounting to £62,500.

E. T. Syndicate, Limited.—The registered office of this company is situate at 2, Victoria Mansions, Victoria Street, Westminster.

Fischer Electro Amalgamator Company, Limited.—The registered office of this company is now situate at 15, Queen Street, E.C.

Phosphor Bronze, Co., Limited.—The annual return of this company made up to the 5th ult. was filed on the 11th ult. The nominal capital is £150,000 in £10 shares. 7,491 shares have been allotted, and upon 6,592 shares £10 per share has been called up, and £5 per share upon the remaining 899 shares. The calls paid amount to £70,415.

CITY NOTES, REPORTS, MEETINGS, &c.

Oriental Telephone Company, Limited.

THE sixth ordinary general meeting of this company was held at the Cannon Street Hotel, on Tuesday, under the presidency of Mr. William Addison.

The directors' report stated that the profit and loss account for the year exhibits a credit balance of £3,569 17s. 6d., which shows a slight improvement on the returns of the previous year, in spite of irregularities on the part of the late manager at Mauritius, a loss on the working of the Colombo branch, together with the further heavy fall in the Eastern exchanges. The improvement is in some measure due to reductions in the London expenses. The Indian guarantees are still a very heavy burden on the resources of the company, but full provision has been made for last year's claims in respect thereof in the item of £4,436 3s. 5d. Although the expansion of the Indian revenues has been very slow, and some withdrawals of exchange subscribers have taken place, owing to financial failures and the general depression of trade, on the whole, the results from India are better than last year. The local companies in Bombay and Calcutta are now introducing the "Magneto" system throughout their "exchanges," and it is hoped that with a more efficient service thus provided, a considerable increase in the number of subscribers at each place will follow. From Bombay latterly the advices have been much more encouraging. Your directors have thought it advisable to re-value the stores on hand at the various agencies, and the result is that an amount of £480 16s. 11d. has been written off, chiefly on the value of instruments which had been sent out in the earlier days of the company, and which have been found to be unsuitable. A sum also of £305 7s. 11d. has been charged in respect of the Egyptian indemnity, the £1,000 reserved on this account having proved insufficient to meet the expenses in connection therewith. After writing off all the above items, the balance remaining to the credit of profit and loss is £2,292 10s. 4d., which it is proposed to carry forward. It has been found necessary to make several alterations in regard to the management in the East, and the result has been beneficial. The question of the rights of the company in Australasia has occupied a considerable time in the deliberations of the board, and will continue to engage their serious attention. Your directors are glad to be able to report an increase in the revenues of the subsidiary companies—notably in that of the Egyptian Company—the shares of which are almost entirely held by your company. The Egyptian Company has earned and paid during the past year 5 per cent. on the issued preferred capital. Your directors would point out that these shares, although of the nominal value of £5 each, are only credited in the balance sheet at a value of less than £2 10s. per share. In China the business has been placed on a better footing, and your directors have accepted from the China and Japan Company £4,200 7 per cent mortgage debentures in settlement of the balance due by that company, whose position now shows a distinct improvement. The present board feeling that the Articles of Association, especially as altered from the original form, place undue power in the hands of the directors, have carefully considered the matter and propose certain alterations giving greater influence to the votes of the shareholders, and these proposed alterations will be submitted to an extraordinary general meeting. You will be asked to authorise the payment of the expenses incurred by the committee of investigation, amounting to £72, and whether the said committee shall receive an award for their services.

Mr. A. B. Chalmers, the secretary, having read the notice convening the meeting,

The Chairman said he thought he would be able show that the progress for the past year had been more satisfactory than wou'd appear from a cursory glance at the accounts. The accounts were now in different form, and would be more readily understood Their holdings of shares in different companies were set out in

a simpler and more intelligible manner, the deferred shares not being included in the valued assets, although as the terms for the guarantees drew near they really became a very valuable property. In the accounts they would see that a sum of £935 was taken credit for last year which really belonged to the year before; it represented the amount of guaranteed interest on the Bengal and Bombay companies' share held by this company in that year. The accounts this time were charged with the item of income-tax, £122, which did not really belong to the year, but to the previous one. Although they were assessed by the Commissioners to the amount of £146 last year, they had, in consequence of their representations that they were not paying a dividend, obtained exemption. In reference to £480 written off for depreciation of stores, half of it hardly belonged to this year, as it was for old material sent out in the early days of the company and which had become practically obsolete. A loss of £350 had occurred on the working at Colombo, and by defalcations in Mauritius; these defalcations were not, however, so serious as was at first expected, and the latest advices led them to hope that £200 would cover the item. Their new agent in Mauritius reported more hopefully of the position generally. Unfortunately their exchanges were in towns which were most particularly affected by the bad times, and the heavy falls in the eastern exchange had largely decreased their profits for the year. During the year the business in Egypt was greatly improved; the directors of the company there had declared a dividend of 5 per cent. as against 3½ per cent. for the previous year. The shares were still valued at less than half their nominal value. Since the accounts for 1885 had been made out the business had steadily continued to improve. The Indian guarantees were gradually decreasing, but not so fast as they wished. The Bengal Company for last year showed a decrease of £650, and the Bombay of £600; the guarantees for the former would expire in May, 1888, and for the latter in September, 1887. After these ceased the deferred shares came in for an equal share with the others, so that instead of having to pay 8 per cent., they would be receiving a per centage on all their holding, whatever it might be. The total number of new subscribers for the year was 537; the withdrawals, caused chiefly by failure and bad times, were 206, leaving a net increase of 331. The total number of subscribers up to December 31st, 1885, were 1,889, as against 1,878 in December, 1884. The total number, up to the latest advices, about the middle of March, was 1,984. The directors had taken £500 for their remuneration for the past year, and proposed to take the same for the current year. They would see that their financial position, with £2,000 deposited at the bankers, nearly £1,000 to current account, and over £600 at their agencies abroad, was by no means unsatisfactory. He moved the adoption of the report and accounts.

Mr. G. A. F. Cavendish Bentinck, M.P., seconded the resolution, which was carried unanimously.

Messrs. Grëwing and Lloyd were re-elected directors, and Messrs. Deloitte, Dever and Griffiths were re-appointed auditors.

Mr. A. H. Baker moved that the £72 which the committee of investigation, appointed about two years ago, were out of pocket in consequence of their proceedings, should be refunded, and that a cheque of 200 guineas, or £25 each, should be presented to them for their services in rescuing the company from certain disaster.

Mr. C. L. W. Fitzgerald seconded the motion, and it was agreed to.

This concluded the ordinary meeting; an extraordinary general meeting followed, at which the following resolutions relating to alterations in the articles of association having the effect of limiting the powers hitherto held by the directors were passed:—

1. That article 56 of the articles of association of the company be altered by striking out the words:—"But this article shall be construed as being only directory."

2. That article 60, clause (*a*) be altered by the addition of the following words:—"Provided that the total amount for the time being owing shall not, without the previous consent of a general meeting of the company, exceed £10,000."

To add the following words at the end of amended clause (*c*) of the same article after the words "or other interests":—"But the authority hereby conferred is not to be deemed to authorise the sale of the entire business or undertaking of the company without the previous consent of a general meeting."

That clause (*d*) in the same article be rescinded and the following substituted:—"They may from time to time appoint any one or more of their number managing director or managing directors, with such share or proportion of the remuneration payable for the time being under article 58, and for such period as they deem fit."

To add the following words to clause (*e*) of the same article:—"Subject to confirmation at the next annual meeting."

To insert in clause (*f*) of the same article, after the words "they may," in the first line, the following words, viz.:—"Subject to the limitations imposed by paragraph (*a*) of this article."

3. That article 61 be altered by the addition of the following words after the words "the continuing directors" in the first line:—"So long as their number for the time being is not less than five."

4. That article 64 be rescinded, and the following be adopted in its place:—"No contract or arrangement entered into by or on behalf of the company with any company, corporation, or partnership, of or in which any director shall be a member or otherwise interested, shall be avoided, nor shall any director being such member, or so interested, be liable to account to the company for any profit realised by any such contract or arrangement by reason only of such director holding such office, or of the fiduciary relation thereby established; but no such director shall vote in respect of any such contract or arrangement."

Reuter's Telegram Company, Limited.

The twenty-second ordinary general meeting of this company was held at the offices, 24, Old Jewry, on Thursday, when the following report was presented:—

The directors beg to submit the accounts for the year ending 31st December last, which show, after payment of current charges, and deducting rebate on unexpired subscriptions a credit balance of £613 5s. 10d.

In the circular issued last October, the shareholders were informed of the heavy expenses entailed by the successive campaigns in the Soudan and the Anglo-Russian crisis. The anticipations which were then entertained, that the exceptional state of political affairs had ceased were unfortunately not realised, the Servo-Bulgarian and the Burmese wars having followed immediately afterwards.

The directors regret that, owing to these causes, the results of the year's operations do not admit of a dividend being declared. They have, however, the satisfaction to announce to the shareholders that new arrangements have been entered into with the Press, which provide for future exceptional expenditure in time of war or prolonged political disturbance.

The directors regret to have to record the death of their esteemed colleague Mr. James Sydney Stopford. It is not proposed to fill up at present the vacancy thereby created on the board. In conformity with the articles of association, Admiral the Right Hon. Sir John C. D. Hay, Bart, K.C.B., retires from the direction, but offers himself for re-election. The auditors, Messrs. Quilter, Ball & Co., also offer themselves for re-election.

[Our report of the meeting will appear next week.]

The Indo-European Telegraph Company, Limited.

The nineteenth ordinary general meeting of this company was held at the Cannon Street Hotel, on Wednesday, when the following directors' report for 1885 was presented:—The company's revenue from all sources for 1885 amounted to £116,150 3s. 1d. as compared with £98,103 11s. 9d., showing an increase of £18,046 11s. 4d., or rather more than 18 per cent. The expenses were: on commercial and general account, £26,509; on maintenance account, £25,088 8s. 11d., including £145 5s. 11d. paid to the Russian Government; total £51,597 8s. 11d., as against £53,323 19s. 6d., a decrease of £1,726 10s. 7d. This is owing to the exceptional outlay on the duplicate Kertch cable which appeared in last year's accounts. The maintenance expenditure, however, includes the cost of alterations and improvements in the company's lines. On commercial account there is an increase of £1,637 7s. 7d., mainly occasioned by staff for additional through circuits and the expenses attendant upon the increased business done. Deducting the above expenses, taking credit for £4,578 11s. 7d. balance brought over from 1884, and debiting income tax, there remains the sum of £67,456 5s. 1d. From this amount £10,625 has already been paid for interim dividend, leaving a balance of £56,831 5s. 1d. The directors, after setting aside £15,000 to the reserve fund, propose the declaration of a dividend for the last six months of 17s. 6d. per share, making, with the interim dividend already paid, 6 per cent. for the year, and a bonus of 30s. per share, both free of income tax, making in all 12 per cent. for the year, and carrying forward £1,456 5s. 1d. to the credit of 1886. The extra cable circuit secured by the new agreement with the Post Office, and the other additions made out of revenue to the company's system, aided by the second wire granted by the German Government, by which two special circuits are secured from London to Teheran, continue to prove of great advantage to the working of the company's system. The above improvements have also contributed to enable the company to deal satisfactorily with the additional business thrown upon the lines during the past year. The large augmentation of revenue is quite exceptional and is owing to the total interruption of the Eastern Company's line for some three weeks, the disturbances in Burmah and the Afghan Frontier question, and it is satisfactory that the £18,046 11s. 4d. of additional revenue has only occasioned an increased expenditure on commercial account of £1,637 7s. 7d. At the Telegraph Conference of Berlin, in response to the desires expressed by the Indian Government and the German Postmaster-General, His Excellency, Dr. von Stephan, it was determined to reduce the rate to India from the 1st of July next from 4s. 7d. to 4s. per word. This will cause a diminution of the company's revenue, but the Board were of opinion that the time had come for a material reduction in the tariff. Reductions were also arranged for, to Australia and China, the amounts of which are not yet fixed, to take effect from the same date. The following directors retire by rotation, and offer themselves for re-election:—Colonel James Holland and H. H. Meier, Esq.

[In consequence of the occurrence of Good Friday this week, we have to go to press a day earlier, and therefore postpone till next week our report of the meeting.]

The Eastern Telegraph Company, Limited.—This Company announces the payment, by interest warrants, on May 1st next of interest for the half-year ending April 30th, 1886, on its 4 per cent. mortgage debenture stock.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending April 16th were £2,466, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 15th April are £3,927, as compared with £4,033 in the corresponding period of 1885.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending April 16th amounted to £2,964.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

REPLY OF THE PRESIDENT TO THE DISCUSSION ON HIS INAUGURAL ADDRESS ON SELF-INDUCTION.

(*Continued from page* 362.)

IF we reduce the extra currents by employing thin sheets or strips, there is in the case of iron a still more remarkable difference, for in strips of different metals of the same width, the force of the extra currents in iron is actually less than that of brass, and if we compare an iron strip with an iron or copper wire of the same resistance, we have iron wire 500, copper wire 100, and the iron strip 45, or actually 55 per cent. less than the copper wire.

In the case of wires a nearer approach to equality in inductive capacity is shown when they are of the same resistance, but in strips this is reversed, for here, when equality in resistance is produced by wider strips, the difference becomes greater, iron then having actually less inductive capacity than a lead wire of the same resistance.

This extraordinary result must be due, not only to the reactions of contiguous portions of the current being less in sheets or strips than in wires, but also from an imperfect formation of the circular magnetism which takes place in all iron wires on the passage of an electric current. This, however, is only a partial cause, as we can obtain a still further reduction of the extra currents by employing numerous fine wires separated from each other, the circular magnetism in the latter case being perfectly formed in each wire; but we still have the maximum experimental reduction due to the separated portions of the current no longer acting on each other. Copper and all metals show a similar reduction when we separate the wires of a strand conveying a current, but when the numerous wires are brought close together, copper approaches in value that of a solid wire, whilst iron wires are but comparatively little influenced by their closer proximity.

I have tried all forms of conductors, such as square, stellar, tubular, &c.; they all show a gradual diminution of inductive capacity as compared with those of a solid circular section; in a solid conductor the maximum effect being obtained in the circular section, and the minimum in that of a wide flat sheet.

We can reduce the self-induction of any metal far below the comparative force that I have given, by widening the strip or, still better, by diminishing its thickness as we widen it, and it is evident that if we keep the same width and gradually increase its thickness, we then approach the conditions of a solid wire; consequently, where it is necessary that we should be able to utilise a given amount of copper in the best possible form, so as to convey a current of an enormously high tension but of short duration, as required in a lightning rod, we should widen the conductor as much as the mechanical stability and durability of the conductor will allow, and I believe that a lightning conductor of copper 1 mm. thick by 10 cm. wide would satisfy the mechanical requirements whilst preserving the physical conditions necessary for a perfect conductor.

My experiments have shown clearly that a solid iron rod is unsuitable for a lightning conductor; but we may use a stranded iron wire or a flat iron sheet of the same conductivity as the copper. The iron wires should be galvanised, as all iron wires coated with a non-magnetic metal show a marked reduction in their inductive capacity; and here, as well as in the ribbon form of copper conductors, practice has guided our inventors in the right path, for it is an almost universal practice to galvanise iron wires in order to preserve them, and ribbon copper lightning conductors have been gradually replacing the most objectionable iron rod, for which there can be no defence based on experimental or scientific reasoning.

I have already given the results of a compound wire of copper and iron made by myself, but I have since (through the kindness of Mr. W. H. Preece) been furnished with some most admirable specimens of American compound wires, the copper being electro-deposited upon a core of steel wire, and also some specimens in which the core is of copper with a steel exterior. I have thus been enabled, not only to verify my previous results, but to prove that an exterior coating of copper has a most powerful influence in reducing the self-induction of its steel or iron core; for, if we take a given length of this wire and compare it with a similar length and diameter of copper wire, and taking for comparison the copper as a standard of 100, we have only 107, or 7 per cent. increase, for the compound wire, but if we file off the copper so as to leave the steel core bare, the inductive value of this same wire rises to 350.

In order to study this effect, let us place an iron wire in the interior of a closely fitting copper tube, and insulated from it: this has no effect upon the iron wire; but if we join the exterior copper tube to the interior iron wire at both ends, the current passes through both at the same time, and the inductive capacity of this compound system is reduced almost to that of solid copper, as previously observed in the compound wires. These effects can be fully explained, when we reflect that the circular magnetism produced by the passage of an electric current through an iron wire is produced only upon the exterior portion of the wire, and cannot take place when this exterior is, as in a compound wire, of copper; consequently a steel or an iron wire coated with copper of sufficient thickness, is entirely free from this magnetic reaction.

Now, if an exterior coating of copper has such an effect in reducing the self-induction of its iron core, it follows that an opposite effect should be produced by coating a copper wire with iron. Experiments with this, and also with a copper wire inserted in a closely fitting iron gas tube, prove that the effect was as foreseen, viz., a remarkable increase in the inductive capacity of the wire.

One result, however, which I did not foresee, although it is clearly indicated in the experiments quoted in my paper, is that not only is the inductive capacity of the interior copper wire increased to a great degree, but that a copper wire coated with iron has a higher degree of self-induction than a sold iron wire; in fact, its inductive capacity is not only higher than is possible to obtain from the softest iron wire, but its *resistance in the variable period* is proportionally greater than any yet remarked in a solid iron wire. I have made numerous experiments on this subject, and they all show that whilst copper in a straight wire or a single *wide* loop has a far less inductive capacity than iron, it has, on the other hand, the property of being far more excited by the reaction of iron, so that a straight copper wire can be excited by this reaction to a degree greatly exceeding that of a straight iron wire under precisely the same conditions.

I will cite a few experiments which illustrate this point. A copper and an iron wire of equal resistance, and 1 mètre in length, were measured for their inductive capacity and resistance, the inductive capacity of the copper wire being as 100, as compared with 400 for the iron. The resistance of the copper in the variable period had only 8 per cent. increase, compared with 128 per cent. for the iron; but a great change took place when each of these was placed in the interior of an iron gas tube of sufficient diameter to allow of the wire being insulated. The force of the extra currents in the copper wire then increased 350 per cent., whilst the iron increased but 8 per cent.; the force of the extra-currents being now for copper 450, against 433 for the iron.

The influence of an exterior iron tube on the resistance of the wire during the *variable* period was still more marked. The copper wire, which without the exterior iron tube had only 8 per cent. increase, now showed 934 per cent. increase, or, by direct measurement, 1 mètre of this wire, during the rapid rise and fall of the current as in the variable period, had precisely the same resistance as 10·34 mètres in the stable period, or a much greater difference than I have obtained from an iron wire; for the iron wire insulated in the gas tube only showed an increase due to this tube of 22 per cent., giving a total of 178 per cent. difference, or, by direct measurement, 1 mètre of the iron wire with its insulated iron sheath, in the variable period, requiring 2·78 mètres to balance it in the stable period; thus copper shows more than three times the sensibility to an exterior sheath of iron than an iron wire itself. Iron appears to be self-contained, and, as regards self-induction, comparatively less acted on by an exterior influence. This is well shown in the case of coils, where the induction of a coil of insulated iron wire is but slightly increased by its own reactions, or those produced by the introduction of an iron core, as in an electro-magnet, whilst copper coils with an iron core show a remarkable increase. We can thus easily obtain extra currents of ten times the electromotive force of those from an iron coil of the same length, resistance, or diameter; and the resistance of a copper coil, which in the stable period may be far less than that of an iron coil, can, by means of its increased self-induction from the reaction of its iron core, be greater than that of an iron wire coil. At first glance this may be considered unfavourable for copper; but we must remember that whilst copper, in the presence of iron, can be excited to a far higher degree than iron, and consequently has stronger extra currents and greater proportional increased resistance in the variable period, this is really a measure of the work it is capable of doing, for we are able by means of this property to obtain the high efficiency of transformation of energy as in the secondary currents. In point of fact, a dynamo machine having its electro-magnet and armature wound with insulated iron wire would, irrespective of its resistance, have an extremely low efficiency as compared with those wound with copper; and as regards the resistance of either of these wires, there can be no doubt that the resistance of the armature of a dynamo, or, in fact, of any coil of wire as measured during the stable period, gives no approximate indication of what its *real* resistance is during the period in which it is doing work.

The following table shows the influence of an iron tube sur-

rounding a straight iron or copper wire, compared with compound wires :—

Wires and Iron Tube each 1 metre in length.	Comparative Electromotive Force of the Extra Currents.	Approximate Comparative Increased Resistance during the Variable Period (that of the Stable Period being taken as 1.)
Copper wire, 2 mm. diameter, alone	100	1·08
Same wire insulated in the interior of the iron tube	450	10·34
Same joined to the tube at both ends	275	10·00
Same in contact with the tube throughout its length	200	7·83
Compound wire (copper interior with steel exterior)	325	4·35
Soft Swedish iron, 2 mm. diameter, alone	400	2·28
Same wire insulated in the interior of the iron tube	433	2·78
Same joined to the tube at both ends	240	2·70
Same in contact with the tube throughout its length	215	2·60
Compound wire (steel interior, copper exterior)	107	1·20

The table shows that the iron tube has a much greater effect upon the copper wire than on the iron wire, the effect in both cases being at its maximum when the tube is insulated from its central conducting wire, for when the wire is in contact with its tube there is evidently a shunt action, or species of eddy current, formed between the outer coating and the central portion. This I have been enabled to measure by interposing the telephone between the inner core and the sheath, or still better, by employing a double insulated sheath of iron or copper, and joining them together at one extremity, the opposite ends being joined through the telephone; by this means we are enabled to measure the differential effects of the secondary currents generated in an inner and in an outer sheath.

The table also shows the effect of joining the outer sheath at both extremities, thus allowing a true eddy current to form; this at once reduces the electromotive force of the extra currents, but has but little effect on the differential resistance in the variable period. If, however, we place the wire in contact throughout, so that the effect from the centre to the exterior of each portion can at once be partially neutralised, then there is a marked decrease in its resistance; and if, as in a compound wire, the exterior coating is in direct and still more intimate contact with the inner core, we then have the maximum reduction. We can thus prove that the shunt effect, or partial neutralisation of the extra currents, takes place locally, and probably transversely. We see also, by its effect on the reduction of the resistance during the variable period, that the passage of an electrical current then takes place with less opposing resistance from the self-induction than could be the case if there were no internal partial neutralisation of the extra currents. No doubt this effect also occurs in sheets and strips, and has its influence in causing the remarkable reduction of self-induction that I have already shown.

In conclusion, I once more desire to express my thanks to all who have taken part in the most interesting discussion that has followed the reading of my paper. Mr. W. H. Preece and Prof. Forbes, who have seen my experiments, have borne testimony to the truth and care with which I have carried out these researches; and our well-known American electrician, Mr. Frank L. Pope, has cited examples showing that the superiority of a stranded iron wire was noticed even in the early days of telegraphy, and that the superiority of a compound wire over an ordinary iron wire is a well-known practical fact in the United States. He has also cited a case similar to the experiments of Prof. Guillemin and myself, where an electro-magnet was destroyed by lightning, notwithstanding that the telegraph line was joined direct to earth in advance of the electro-magnet. I am glad that many of the results of my researches are fully borne out by the practical experience of the past; and I hope that those which have as yet not been foreseen in theory or applied in practice will receive the same attention and verification that all discoveries should undergo, as I feel convinced that their truth will become more and more evident when repeated in the laboratory or applied in practice.

Physical Society, March 27th, 1886.

Prof. W. G. ADAMS, Vice-President, in the Chair.

Mr. A. R. Wright was elected a member of the Society.

The CHAIRMAN read a letter from Dr. Alder Wright, Secretary to the "Tribe Fund" Committee, in which reference was made to the scientific work of the late Mr. Alfred Tribe, and an appeal made for funds to aid in the maintenance and education of his family, which, owing to his early death, has been left in straitened circumstances.

The following communications were read :—

"On an Arc Lamp Convenient for Use with the Duboscq Lantern," by Prof. S. P. THOMPSON. The old Duboscq lamp, though working well with a series of Grove's cells, is very unsuitable for use with currents from dynamos. Prof. Thompson has employed as a substitute in the Duboscq lantern a lamp commonly known as the "Belfast arc lamp." The result is all that can be desired as regards steadiness and regularity. The "focussing," that is, the adjustment of the arc so that it should remain unchanged in position, is effected by a wheel below the lantern, which is moved by hand.

"On a Modified Maxwell's Galvanometer," by Prof. S. P. THOMPSON. The galvanometer consists of a light frame of copper upon which is a coil of wire. This is suspended between the poles of a horseshoe magnet, and a piece of soft iron is placed within the coil but free from it, which concentrates the magnetic force between the poles. The coil is suspended by two silver wires, by which it is in connection with two binding screws on the base of the instrument. This galvanometer is extremely simple in adjustment and very dead beat, it has also the advantage of being affected to an inappreciable extent by neighbouring magnets and currents, with a current in its own coils; when no current is in it, it is, of course, quite unaffected. The reading is effected by the ordinary lamp, mirror, and scale arrangement.

"On the Expansion of Mercury between 0° and − 39° C. by Profs. W. E. AYRTON and JOHN PERRY. Oh November 14th, 1885, Mr. G. M. Whipple gave the Society the results of the examination of thermometers down to the melting point of mercury. There was, however, no evidence as to whether the contraction of the mercury continued uniform, as the thermometers were only compared with mercurial ones. The authors have therefore examined this point and have made a series of comparisons of a mercurial thermometer, lent them by Mr. Whipple, with a constant volume air thermometer, both immersed in a bath of frozen mercury which was allowed to gradually become warm. The result obtained was that no certain deviation from a linear law could be detected in the expansion of mercury when temperature was measured by the increase of pressure required to keep a volume of air constant. Hence temperatures down to − 39° C. may be correctly measured by a mercury thermometer the stem of which is graduated for equal volumes.

"On the Expansion produced by Amalgamation," by Profs. W. E. AYRTON and JOHN PERRY. It has been accidentally observed by the authors that the amalgamation of brass is accompanied by great expansive force. If one edge of a straight thick brass bar be amalgamated, it will be found that in a short time the bar is curved, the amalgamated edge being always convex, and the opposite concave. The authors imagine that a similar action may be the primary cause of the phenomena presented by the Japanese "magic mirrors." Japanese mirrors are made of bronze and have a pattern cast upon the back, and although to the eye no trace of it can be discovered upon the polished reflecting surface, yet, when light is reflected by certain of these mirrors on to a screen, the pattern is distinctly visible in the luminous patch formed. In a paper before the Royal Society they have shown that this is due to the polished side opposite the thinner parts of the casting being more convex than the others, a conclusion verified by the fact that the pattern is reversed when formed by a convergent beam of light. Such a condition of things would evidently result from an uniform expansive stress taking place over the reflecting surface, the thinner, and consequently the weaker, parts becoming more convex or less concave than the others. The authors have hitherto attributed this inequality of curvature to a mechanical distortion to which the mirrors are intentionally submitted during manufacture, to produce the general convexity of the polished surface, but they now think it possible that the use of a mercury amalgam in the process of polishing may have an effect in the production of this inequality of curvature.

APRIL 10th, 1886.

Prof. BALFOUR STEWART, President, in the Chair.

The following communications were read :—

"On the Cause of the Solar Diurnal Variations of Terrestrial Magnetism," by Prof. BALFOUR STEWART, L.L.D., F.R.S. The author commenced by reviewing various theories that have been advanced to account for the solar diurnal inequalities of terrestrial magnetism. That they can be due to the direct magnetic action of the sun is highly improbable, since terrestrial analogies would lead us to infer that matter at the temperature of the sun is quite incapable of possessing magnetic properties, and also from the fact that changes in the range of the daily variation lag behind corresponding solar changes in point of time. The hypothesis of Faraday, that the observed variations are the result of the displacement of the magnetic lines of force due to the varying temperature, and consequently varying magnetic permeability of the atmospheric oxygen, is disproved by the fact that there is no agreement between the chief magnetic variations and those of the temperature of the great mass of the atmosphere, though it is certain that there must be some effect due to this. The earth-current hypothesis is quite unable to explain one of the chief characteristics of these variations, that they are half as great again at periods of maximum as at those of minimum sun-spot frequency; Sir George Airy has, moreover, been unable to detect any resemblance in form between the regular diurnal progress of the magnet and that of earth currents. We seem, therefore, compelled to seek for the cause of the variations in the upper

atmospheric regions, and we cannot imagine such a cause to exist in any other form than that of a system of electrical currents. That currents may, and actually do, exist at great heights is shown by the Aurora, which is unquestionably an electric current and manifests a close connection with the phenomena of terrestrial magnetism. The great increase of magnetic variation at epochs of maximum sun-spot frequency can also be accounted for on this supposition. Prof. Stokes has remarked that an increase in the radiating power of the sun would probably imply, not only an increase in general radiation, but a special and predominant increase in such actinic rays as are probably absorbed in the upper regions of the earth's atmosphere. These regions will, therefore, greedily absorb the new rays, their temperature will rise, and, as is known to be the case for gases, the electrical conductivity will be increased. Thus, even if we imagine the general atmospheric current to remain constant, a greater proportion of it would be thrown at such times into those heated portions which had become good conductors, but it is also probable that the current itself would be increased. Assuming the existence of currents at great altitudes, the regularity and general characteristics of the diurnal variations would seem to point to a direct magnetic action of the currents, rather than to any general induced change in the magnetic system of the earth, which, to produce the observed results, would have to be of a very artificial character. The diurnal variation of the declination, attaining a westerly maximum at 2 p.m., north of the equator, and an easterly maximum at the same time south of it, would suggest the existence of currents flowing northward and southward from the equator to the poles, attaining a maximum in each hemisphere about two hours after the sun had passed the meridian. To supply this flow we should probably have to assume the existence of vertical currents ascending from the equatorial regions of the earth. At this point Dr. Schuster had endeavoured to apply mathematical analysis to the subject. From the recorded observations at Greenwich, Lisbon, Hobarton, St. Helena, and the Cape, he has shown that the work done by a magnetic pole describing a closed path in a horizontal plane at those places is equal to the work done upon it, and consequently no part of the ascending current can be enclosed by the path. Hence the potential at those places obeys the law expressed by the equation

$$\frac{d^2 v}{d x^2} + \frac{d^2 v}{d y^2} + \frac{d^2 v}{d z^2} = 0.$$

From this, Dr. Schuster has deduced two possible expressions for the potential, one referring to a system of currents above our heads, and the other to one beneath our feet. From the first of these expressions it follows that for latitudes greater than 45°, the maximum of horizontal force should coincide with the minimum of vertical force, and *vice versa*, and this is actually the case at Greenwich: while the opposite should hold if the influencing system were beneath us. For latitudes below 45° the reverse of the above should be the case, and the observations at Bombay, though less decided than those at Greenwich, would seem to point the same way. On the whole, then, it must be said that the results of the first attempt are very encouraging, and point to the supposition that the greater part of the disturbing cause lies outside the earth's surface.

In a discussion that followed, Mr. WHIPPLE remarked that recent observations in high latitudes seem to show that the Aurora is not always at such a great height as is usually supposed. Prof. A. W. Rücker cited the well-known case when an observer saw what appeared to be a meteor fall into the sun, while simultaneously, or nearly so, there was recorded a magnetic disturbance on the earth, as showing a direct solar action. Mr. Whipple, however, stated that he had recently examined this point, and believed that the very slight notch in the record, many similar to which have occurred since, was of an accidental nature, and a mere coincidence.

Prof. MCLEOD suggested that the earth-current theory might be tested by observations at the bottom of a mine, where, according to the theory, the disturbances should be reversed.

Prof. ADAMS believed that there was nothing physically impossible in the existence of such currents as the author imagined.

"On a Relation between the Critical Temperatures of Bodies, and their Thermal Expansions as Liquids," by Prof. A. W. RUCKER, F.R.S., and Prof. T. E. THORPE, Ph.D., F.R.S. A paper by the authors bearing the above title was published in the *Journal of the Chemical Society* of London for April, 1884. The substance of the paper was as follows: Prof. Mendelejeff has shown that the expansion of liquids under constant pressure between 0° C. and their boiling points may be expressed by means of the very simple formula

$$v_t = \frac{1}{1 - k\,t.}$$

v_t being the volume at $t.°$ C. (that at 0° being unity) and k a quantity which differs for different substances but which may for any one substance be considered invariable between 0° C. and the neighbourhood of the boiling point. From this law the authors have obtained as a deduction the following expression for the critical temperature (T_c) of any liquid

$$T_c = \frac{T\,v_t - 273}{a\,(v_t - 1)}$$

where v_t is the volume at $t.°$ C., T the absolute temperature, and a a quantity which is very nearly constant for all substances, and which was shown to be very nearly 2.

In a recent paper (*Ann. Ch. Ph.*, March, 1886,) MM. A. Bartoli and E. Stracciati have discussed both of these formulæ, and have applied them to cases in a manner never intended by the authors. They have expanded Mendelejeff's formula into the series

$$v_t = 1 + k\,t + k^2\,t^2 + k^3\,t^3 \ldots\ldots$$

which is a geometrical progression, and they have objected that the results of Pieire, Kopp, Hirn, Thorpe, &c., do not give for the coefficients of t, t^2, t^3, quantities in geometrical progression. The results of these observers are given in the usual form

$$v_t = 1 + a\,t + b\,t^2 + c\,t^3 + \ldots$$

but owing to unavoidable errors of experiment the constants c, d, of different observers differ very largely, and Mendelejeff's simple expression gives the results of all quite as accurately as the facts will allow. MM. Bartoli and Stracciati have then criticised the expression given by the authors, and have applied it to determine the critical temperature of water from its expansion to 200° C., whereas the original expression is only given as applicable as far as the boiling point. They have further recorded a number of critical temperatures calculated by the formula to tenths of a degree, for which the constant a would require to be known to ·025 per cent., whereas there is no reason for supposing it known to within one per cent., or more.

NEW PATENTS—1886.

5168. "Electric lighting of trains." R. E. B. CROMPTON, J. SWINBURNE. Dated April 14.

5176. "Dynamo-electric and electro-dynamic machines." C. L. BAKER. Dated April 14.

5215. "Electrical batteries." A. CAMPBELL. Dated April 14.

5218. "Electrometer." B. PELL. Dated April 14.

5223. "Insulating materials for electrical purposes." P. WARD, S. J. BLANE, Bart. Dated April 14.

5242. "Electric arc lamp." J. L. BALBI, F. TOLLEY. Dated April 15.

5250. "Couplings and fastenings for coupling the ends of ropes containing an insulated wire and for securing the ends of such ropes to grapnels." H. KINGSFORD. (Communicated by S. Trott and F. A. Hamilton.) Dated April 15. (*Complete.*)

5273. "Arrangement for mounting and driving dynamo-electric machines." H. P. HOLT. Dated April 15. (*Complete.*)

5276. "Telephonic apparatus." E. BERLINER. Dated April 15. (*Complete.*)

5298. "Secondary voltaic battery." C. MOSELEY. Dated April 16.

5338. "Governing dynamo and other machines" W. T. GOOLDEN, A. P. TROTTER, H. W. RAVENSHAW. Dated April 16.

5341. "Mechanical telephones." E. P. ALEXANDER. (Communicated by H. Lamont.) Dated April 16.

5381. "Electrical contact apparatus." A. DE KHOTINSKY. Dated April 17.

5409. "Dynamo machines." L. BOLLMAN. Dated April 19.

5437. "Electric arc light." A. N. J. CONTARINI, N. CONTOPOULOS. Dated April 19.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1885.

3525. "Improvements in apparatus for distributing and utilising electricity." R. P. SELLON and J. S. SELLON. Dated March 18. 8d. The object of the invention is to provide means whereby a current of high tension may readily and simply be converted into one of low tension, without the necessity of employing secondary batteries or other intermediate converting appliances, for attaining this end, and means for regulating the speed of motors, so that a constant or any desired ratio of difference in speed may be maintained of the motors, whether they are doing useful work or merely running idle. The inventors employ a dynamo-electric or electro-dynamic machine, of which the revolving armature is wound with two distinct and independent sets of coils, each set of coils being carried to a separate commutator or collector. The iron of the field magnets of this armature is common to both sets of coils of the armature, but the field magnets have coils so arranged that a portion is in connection with the first set of coils upon the armature and a portion is in connection with the second set of coils upon the armature. By this arrangement they obtain what may be called a "motor generator" inasmuch as the passage of a current through one set of coils upon field magnets and its corresponding armature coils will cause a revolution of the armature to take place, the speed of such revolution being mainly dependent on the intensity of the magnetic field in which it revolves. This revolution will cause the second set of coils upon the armature to be likewise drawn through a magnetic field, and thus a current will be set up in the coils of the second portion of the armature, which may be used for any purpose, for example lighting or heating.

4506. "Improvements in telegraphs." C. LANGDON-DAVIES. Dated April 11. 8d. According to this invention telegraphic signals are transmitted by means of induction coils furnished

with vibrators, and in conjunction with electrophones in such a manner as to permit of one or more electrophonic transmissions simultaneously with the ordinary telegraphs.

4541. "Improvements in electric telephony." J. G. LORRAIN. Dated April 13. 6d. Consists in employing as charging batteries for the transmitting and receiving instruments a series of secondary couples or accumulators, arranged so that they can be themselves charged in quantity by a primary battery, or other source of electricity, and then when required they can be arranged in series for charging the transmitters or receivers.

4688. "Improved carrier or support for incandescent lamp shades." A. SWAN. Dated April 16. 6d. Three arms made of thin hammered brass (or other suitable material) radiate from a common centre, and are so shaped and bent, as to form a spring; each arm of the spring at its termination being turned down and inwards, so as to form a claw. A loose ring, forced over the spring, presses the arms together, and this has the effect of closing the claws upon the projecting flange of the shade, and so supporting it. The "eyelet," or disc, from which the arms of the spring radiate, is furnished with a tapped ferrule, to any required size to suit either a nozzle for flexible cord, or for coupling on to a fixed electrolier.

4771. "Improvement in wiring interiors for electric light and other purposes, and in devices and tools therefore." B. J. B. MILLS. (Communicated from abroad by L. Stieringer and J. H. Vail, both of New York.) Dated April 17. 8d. Consists in the use of staples or hooks of insulating material, which are inserted into the supporting woodwork of the structure, or a wood moulding or other suitable insulating backing supplied for the purpose.

4854. "Holder for incandescent lamps." H. PIEPER. Dated April 20. 8d. Consists of two main parts, a plug made of insulating material and a metallic spiral. The plug, which is designed to be attached to the arm or bracket carrying the lamp, is provided on the upper part of its side with a small binding post, to which is connected one of the conducting wires, while the other conducting wire is carried to a screw centrally inserted into the bottom of the plug. The spiral, made of thick wire, constitutes a kind of nut adapted to be screwed with one end on screw threads formed on the lower portion of the plug, and with its other end on the base of the lamp, also provided with corresponding screw threads, a connection between the plug and the lamp being thus produced.

4963. "Improvements in couplings for an electric circuit in connection with the brake pipes of railway trains." W. E. LANGDON. Dated April 22. 8d. To a block of ebonite, or any other insulating material, the invenfor affixes two pieces of metal, or fangs, insulated at that part at which they are attached to the ebonite, the one from the other. One of these fangs he makes rigid, the other consists of a spring so constructed that the end opposite to that at which it is fixed to the ebonite shall make contact with the rigid piece of metal, or fang, previously referred to. The inside of this rigid fang he insulates, leaving uninsulated only such space at the extreme end, as is required to enable the spring fang to form metallic contact with it when at rest, that is, when the coupling is disconnected or uncoupled. The space between the two fangs is regulated by the thickness of the rigid fang. The block of ebonite carrying the said fangs, he fixes in a hood, or cover, and having attached the necessary wires by which the electrical communication is carried through each coach or other vehicle, a hood with its contents is firmly fixed upon each portion of the brake coupling in such a manner, and in such a position, that when the two portions of the brake coupling are connected up, the fangs upon the one portion shall engage with the fangs upon the other portion, and this, so that the spring fang of the one, shall form contact with the rigid fang of the other, and that when thus thrust together, the spring fang shall be forced apart from the rigid fang of its portion of the coupling which in its normal condition it maintains, and the two wires forming the communication attached to each portion of the coupling shall become respectively connected with each other.

5202. "Improvements in galvanic batteries." A. SCHANSCHIEFF. Dated April 27. 4d. The inventor applies directly on to the positive plates of batteries an exterior coating of collodion albumen gelatine, gluten, or such like substance to protect their surface from the direct action of the liquid in which they are immersed, and so avoid local action and render the battery current constant.

CORRESPONDENCE.

Secondary Generators or Transformers.

IN your issue of the 9th inst., wherein you publish the letter in which we claim absolutely the exclusive right to use secondary generators or transformers for the distribution of electrical energy of variable quantity and potential according to the requirements of each individual consumer, you state that the publicity given by you in 1883 to the anterior work of Sir Charles Bright, Messrs. Jablochkoff, Fuller, and others shows the absurdity of our present claim.

In arriving at this conclusion you have evidently forgotten that you cited these anterior experiments to prove the uselessness of the researches that we were making at that time, all the attempts mentioned having remained without any industrial result, owing to the insufficiency of the return obtained by these experimentalists whose value as scientists was much greater than ours.

Sir Charles Bright himself declared, at the meeting of the *Societé Internationale des Electriciens*, at Paris, in February, 1884, that the experiments made by him in 1878 for arriving at the same results as ourselves, and by similar means, only led him to establish a loss of 50 per cent. We have, then, the right to claim that our trial installation on the Metropolitan Railway was unprecedented; it consisted of the distribution, at five of the stations, by means of a circuit 15 miles long and 3 mm. in diameter, of electrical energy in the different forms required for feeding the various apparatus employed there; this fact constitutes a new and consequently patentable industrial result.

It is equally incontestible that in 1884, at the Turin International Exhibition, we positively for the first time transported and distributed over a circuit 82 kilometres long and 3·7 mm. in diameter, electrical work of 50 H.P.; this electrical energy was employed at five different points for lighting all known kinds of electrical lamps.

The industrial development which our system of distribution has now attained renders it impossible to deny that we have been the first to indicate the conditions for the construction of induction apparatus capable of giving a transformation return of 95 per cent.

We therefore rely upon successfully defending in the Courts of Law our patents, which comprise: "A new system of distributing electricity over great distances, and of transforming this energy at an unlimited number of points on one and the same circuit into electrical currents absolutely independent of one another and of every kind, that is, suitable for all purposes such as arc and incandescent lighting, motive power, electro-chemical processes, &c."

You will observe that the great problem of the distribution of electrical energy had never been before defined with precision, and the results which we have obtained are there to prove that our claims are not based upon ideas that can be called Utopian or absurd.

L. Gaulard.
J. Dixon Gibbs.

London, *April 16th*, 1886.

[Messrs. Gaulard and Gibbs misunderstand us. We do not, for one moment, disparage the work done and the results obtained by our correspondents; indeed, whatever may be the ultimate fate of their apparatus, they deserve to achieve success. We again say, however, that these gentlemen were ill-advised in claiming transformers of *any model* for the purpose of distributing electrical energy. Do they include those very models of Bright, Jablochkoff, Fuller, and others, which they admit to be anterior to their own specifications? Because the Willans' engine, as shown in the report on the Crompton dynamo in our last week's issue, is more economical than such motors have been thought hitherto, Messrs. Willans and Robinson might, with as much show of reason, claim any model of high-speed direct-driving engine. Messrs. Gaulard and Gibbs are, doubtless, entitled to the sole right of the mechanical construction as adopted in their induction coils, but other people have an equal right to employ different methods of manufacture, the *principle* being free to all.—EDS. ELEC. REV.]

Measuring Intermittent or Alternating Currents.

In your issue of 9th inst. is a communication from Profs. Ayrton and Perry, in which certain experiments of Captain Cardew's are mentioned. Now isn't it

begging the question to suppose that the Siemens dynamometer, or any such instrument, measures the mean square of an intermittent or alternating current? I have a faint recollection of an investigation of Prof. Mascart's (?) into this question, in some paper of his on alternate currents, which were measured by a Thomson electrometer with needle connected to one pair of quadrants; but I can specifically refer you to a paper by Hospitalier in *L'Electricien*, vol. viii., p. 289, on this subject.

I should recommend experimenters when they ask for mean squares to see that they get them.

F. J.

April 17th, 1886.

Professor Hughes and Self-Induction.

In my letter to you of the 12th inst., published in No. 438 of your journal, I enumerated several novel propositions which Professor Hughes has given for the guidance of the practical electrician.

Now, if I rightly understand the professor's meaning, it follows that if two circuits, one of iron and the other of copper, but both of the same resistance, as determined by the "stable" method, were employed to carry rapid currents, the strength of the working current would be very much less through the iron than through the copper. My experiments were made with a view to test the correctness or not of such a statement. The results I have obtained certainly do not agree with those given by Professor Hughes; for I find it to be practically immaterial of what metal or form the conductor is, providing the resistance is precisely the same. That is to say, Ohm's well-known law, as far as I can judge by the light of my own experiments, appears to be practically correct for "variable" as well as for "stable" currents.

I should not have written you again on this subject had not you, in your comment on my letter, called in question the suitableness of a galvanometer for such an experiment as I explained in that letter.

My object was to ascertain the strength of the working current under variable conditions of the conductor, bearing in mind always to keep the resistance the same. Now I found the galvanometer a most suitable instrument for my purpose, for, when the resistance of the circuit was intentionally altered, it proved very susceptible to the slightest change. When a telephone was substituted for the galvanometer, it appeared, as far as the ear could judge, to be affected the same as the galvanometer. In the case of using reversals, if the connections of the galvanometer be reversed at the same time as those of the battery, a steady deflection would be obtained which would represent the true strength of the working current. I am referring to a mirror reflecting galvanometer, the divisions on the scale of which are, for all practical purposes, directly proportional to the strength of the current. Of course, theoretically, the speed of the interrupter, or reverser, might be such that the galvanometer would be apparently unaffected, while a telephone would be still audibly affected; but that proves nothing more than that the telephone is the more sensitive instrument of the two in an experiment of that kind.

My belief is that, in dynamic electricity, polarisation precedes conduction, in fact that conduction is the result of polarisation, and that there can be no conduction without polarisation; consequently, before an electric current can be produced in matter of any description, size, or form, the atoms composing such matter must all have become polarised by induction. If this be so, it follows that, when a battery or other source of electrical power is applied to a conductor, a certain period of time must elapse before the strength of the current flowing in the conductor reaches its maximum; this period of time is the "variable" or polarisation period, and is that period in which all the phenomena examined by Prof. Hughes takes place, therefore it is most important to know, with some degree of accuracy, its duration, for thereon depends the *practical* importance of the subject in its relation to telegraphy, &c., that is to say, if the duration is so brief as to be infinitesimal, then its practical importance is equally small. It is during this period that the resistance of an iron wire, as measured by Professor Hughes, is stated to be more than three times that of copper.

In my arrangement, a complete circuit was made up of a galvanometer, rapid interrupter, battery and wire under test, the interruptions were exceedingly rapid (about 200 per second), and the probable period of contact during which the circuit was closed must have been less than the $\frac{1}{500}$th part of a second. That being the case, it is clear that, if the "variable" period lasted for the $\frac{1}{500}$th part of a second, then the galvanometer would only be in circuit during the "variable" period, and the deflection would consequently represent the current flowing in the "variable" period alone, and, since the current flowing depends upon the resistance of the circuit, the deflection would indicate the *resistance* in the "variable" period. Now, by this method, an iron wire and a copper wire can be directly compared, and since they have been compared by actual experiment and found to produce practically equal deflections, it follows that either the "variable" period is equal in both cases, or else that the duration of that period is so exceedingly small that, although the circuit is only closed for the $\frac{1}{500}$th part of a second, yet that brief period is sufficiently long to embrace not only the "variable" but also the "stable" period; and, further, that the "variable" period forms so small a part of the $\frac{1}{500}$th part of a second, that the test, although of so brief a duration, is practically a test of the "stable" period. It must be clearly understood that each contact forms an independent test, the galvanometer deflection representing the result of many of these tests superimposed one upon the other.

No doubt the duration of the "variable" period depends upon the work the polarisation has to do; and since, owing to the magnetic properties of iron, polarisation in that metal is called upon to perform a greater amount of work than in other metals, it is quite understandable that, theoretically, the "variable" period for that metal may be of greater duration than with non-magnetic metals. But what I doubt is, whether it is of such practical importance as Prof. Hughes supposes it to be. The question is one of great importance in telegraph systems, especially where high-speed instruments are worked, and I have no doubt but that long ere this it has been practically tested by practical men. If that be so, perhaps those gentlemen will publish the results of their experience; and, should they confirm the view of Prof. Hughes, that gentleman will have again rendered very valuable service in the advancement of our electrical knowledge.

Willoughby Smith.

April 20th.

Incandescent Lamps.

In your report of the adjourned discussion on Mr. Bernstein's paper, an error has crept in.

In my remarks I pointed out that lamps worked on the series system must of necessity have shorter lives than if worked on the parallel system. This fact is quite independent of the character of the lamps. In his reply you make Mr. Bernstein say that my statement "is not correct if the carbons were of proper quality." Mr. Bernstein did not say this. He did not question the accuracy of my statement.

As you last week devoted a leading article to the important subject of life of lamps, this cardinal difference between the effect of constant current and constant potential difference working may be of interest to your readers, and I am anxious that no misapprehension should exist on the point. Perhaps, in justice both to Mr. Bernstein and myself, you may think it worth while to put the matter right.

A. M. Mordey.

April 19th, 1886.